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THE CANET TORPEDO DISCHARGE TUBES.

A TORPEDO discharge tube is a piece of ordnance, but one of a very peculiar kind. Shells and torpedoes are projectiles of so different a nature that there naturally result essential differences in the structure of the apparatus that discharge them. The characteristic property of the torpedo *discharged*, in opposition to the torpedo *carried*, is to be automobile. It suffices to expel it from the torpedo boat, and abandon it to itself in a proper position upon its trajectory, to have it afterward traverse the latter by virtue of its own force of propulsion. The object of the torpedo tube is to effect such expulsions under the most favorable conditions for the travel of the projectile, that is to say, by carefully dissipating all disturbing causes. The causes of deviation are due, for the most part, to the peculiar conditions in which the torpedo boat is placed by reason of its mobility. In the first place, the vessel carries along with it a great mass of water which constitutes a genuine liquid envelope that participates in its motion. If the torpedo be immersed in the midst of this it receives from it an impulsion in the direction of the boat's course, and such impulsion modifies and alters the direction that it was desired to give it. It is therefore expedient to throw the torpedo to some distance, so that it may be sure of reaching calm water.

In the second place, the initial velocity of impulsion of the torpedo itself, at the moment that it is discharged, must be taken into account. As long as the torpedo is fired parallel with the axis of the vessel, such velocity has no influence upon the direction; it simply increases when firing in chase and decreases when firing in retreat. The velocity of the torpedo proper to it is alone modified. When the firing is done at right angles, the case is different. The velocity of the vessel then constitutes a component that forms a greater or less angle with the trajectory of the torpedo, which, definitely, partakes of two motions—one in the direction of the vessel's axis and the other transversal. The latter is quickly destroyed by the resistance of the fluid, immediately after immersion, while the former is kept up by the propeling apparatus contained in the torpedo; but, in order that there shall be no deviation, it is important that the resistance of the water shall act very symmetrically upon the torpedo. Now, if we suppose that the latter enters the liquid point foremost, for example, there may be a chance of its prow being arrested while the part that still emerges is still continuing its lateral travel, thus deflecting the axis of its first direction. In order to obviate this trouble, it is generally agreed in the French navy that it is advisable to immerse the torpedo all in a lump by allowing it to fall flat in the water. On the contrary, the Russians contend that it is better to discharge it at a certain inclination. Without desiring to take sides with either of these absolutely opposite opinions, we think it well to observe that the latter method may have advantages in stormy weather or even when the sea is not very rough. In this case, if the torpedo falls flat, it may be lifted and deviated by the waves before reaching the normal level of the water. On the contrary, if it falls at a certain angle, it immediately penetrates the water and becomes less exposed to the fluctuations of the surface.

The simplest solution of the question would evidently consist in discarding cross firing, and that is the one adopted for small torpedo boats, the tubes of which are generally arranged for firing parallel with the axis only. But what is possible with these small boats, the only *raison d'etre* of which is the torpedo itself, is no longer admissible when it comes to a question of larger vessels. To make the latter perform their evolutions and change their course, without danger, for the sole purpose of presenting their front to the enemy during the few seconds necessary to discharge the torpedo, cannot be thought of. Moreover, aside from all other considerations, there would be a material impossibility of doing it. On the contrary, it is on passing board to board, at full speed, that a cruiser must fire at a favorable distance. Firing crosswise will therefore prove a frequent case that it is well to take into account.

In order to allow the torpedo to fall flat in the water, there are employed what are called "scoop" tubes (Fig. 1). In this system, which was first used by the French navy, the tube, which is of bronze or steel as usual, is prolonged by an inverted "scoop," which resembles, rather, a long visor. The torpedo is then suspended from the top of the tube and "scoop" by a projecting T-shaped tenon engaging in a slot in the tube and "scoop." The length of the latter is such that when the tenon escapes from the slot, the torpedo itself has nothing beneath it, and is therefore horizontal when it falls in the water.

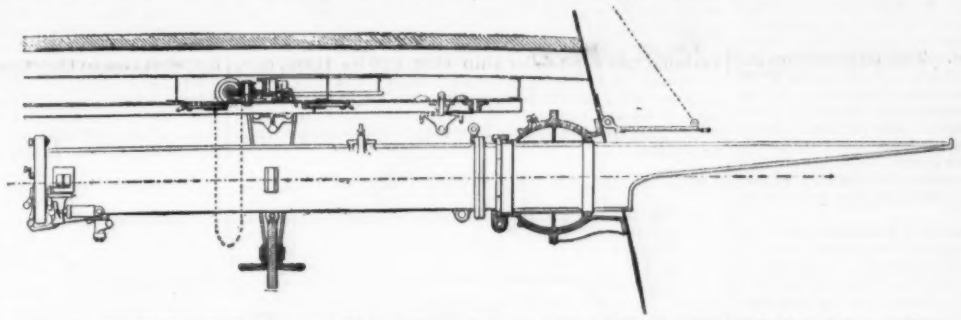


FIG. 1.—CANET TORPEDO DISCHARGE TUBE FIXED UNDER THE BEAMS OF A SHIP.

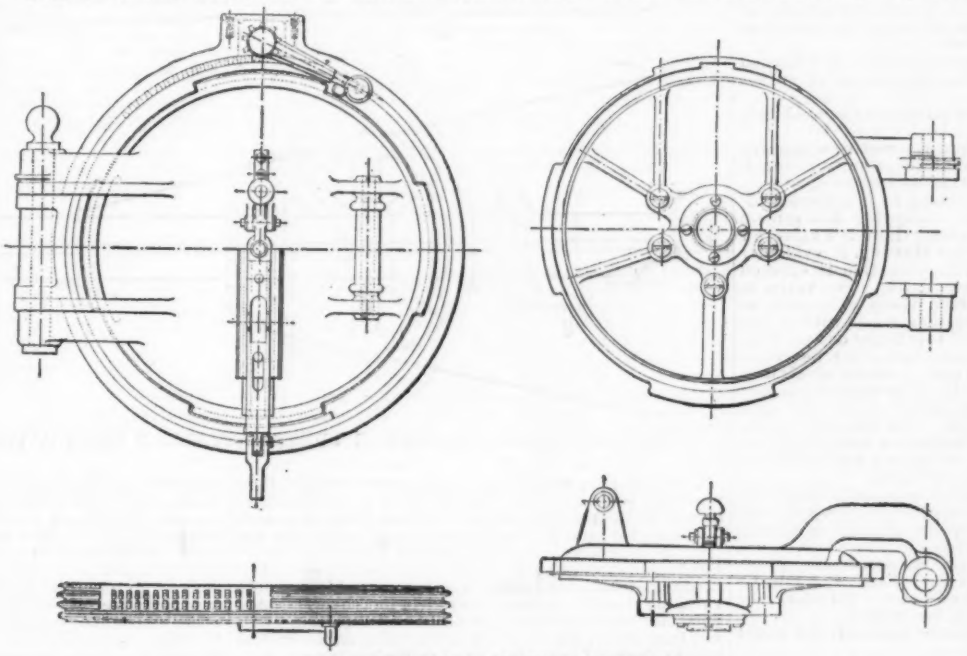


FIG. 2.—DETAILS OF THE BREECH.

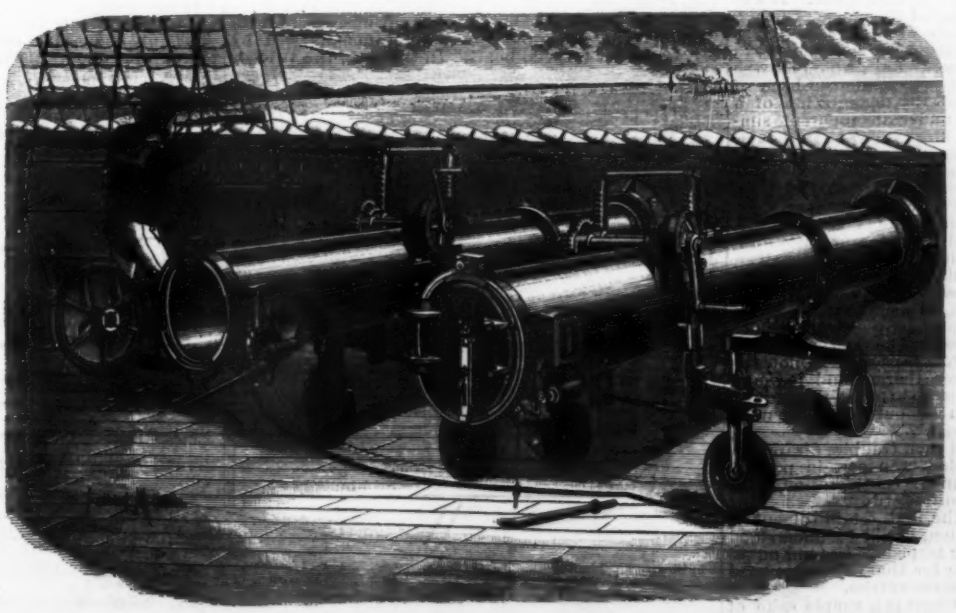


FIG. 3.—CANET TORPEDO DISCHARGE TUBES PLACED ON THE DECK OF A SHIP.

A torpedo discharge tube consists essentially of a long metallic cylinder into which the projectile is introduced from behind. In consequence of the torpedo being spindle shaped, it touches the sides of the tube only according to its greatest parallel—"amidships," so to speak. Nothing would prevent it from oscillating, and even from escaping by its own weight, when the motions of the vessel incline it beneath the horizon, did not the constructor take a few indispensable precautions to keep it immovable until its discharge.

Besides the guide tenon engaging in the upper slot of the tube, and which is sometimes duplicated by a similar one placed in the lower part, the precautions in question consist in making the torpedo abut against a catch or safety bolt projecting from the side of the tube, while the breech piece, in closing, keys the frame of the helix by means of a screw plug which bears against it.

In the Canet apparatus, constructed by the Forges et Chantiers de la Méditerrané, and which form more especially the subject of this article, the gate that closes the tube in the rear has itself some analogy with the movable breech with interrupted screw threads adopted for guns (Fig. 3). It is the same principle, but differently applied, as is befitting in virtue of the peculiar conditions involved. The force necessary for the expulsion of a torpedo, in fact, is much feebler than in the ordinary case of gun firing. It has therefore been possible to simplify the general form of the tube and to lighten it, while at the same time rendering its operation absolutely easy and sure.

The breech is movable on a hinge at the side of the tube, and is provided around its circumference with projecting sectors which, at the moment of closing, engage with sunken sectors in a movable collar arranged at the back of the tube (Fig. 2). This collar itself is provided, upon a portion of its external circumference, with a toothed arc actuated by a pinion and winch. When the breech is closed, it

takes but a few turns to rotate the collar, whose projecting sectors then engage with the corresponding sectors of the breech and lock it tightly. The joint is rendered complete by an asbestos packing inserted in grooves formed in the tube

In order to open the breech, it is necessary to act upon the winch which effects the rotation of the collar; but the disengagement of the breech is automatically signaled, because the winch then abuts against a stop that prevents it from turning any further. It then suffices to pull the breech back in order to uncover the end of the tube.

The various mechanisms that assure of the firing and the freeing of the stop bolt are placed back of the tube upon the breech piece itself. We shall describe them further along.

The mode of expulsion of a torpedo is not an operation that is as mathematically definite as the firing of a shell, for which the conditions must remain exactly the same from one shot to another; but, in return, the kinematic problem is complicated by the necessity of rendering the three following operations simultaneous; (1) the freeing of the bolt in order to put the torpedo in a state to be expelled; (2) the expulsion; and (3) the starting of the motive apparatus contained in the torpedo itself.

In the Canet tubes, the two first operations are effected by a system of lever arms placed back of the tube and mounted upon the same shaft (Fig. 4). One of these arms holds the safety bolt raised and in projection in the chamber. The other lever serves for firing. In order to put it in the position of full cock, a lever is engaged with the socket, and by exerting a stress on this lever and depressing it, a powerful spring, held by a detent, is tightened. In this movement, the firing finger, which abuts under the head of a vertical bolt sliding on the posterior face of the breech, lowers and allows the bolt to descend. This latter carries the percussion hammer, the toothed tang of which gears with a rack fixed upon the breech of the tube. At the moment in which, either by raising the detent by hand or by means of an electro-magnet, the spring is freed, the system of levers is carried backward. On the one hand, the safety bolt, being no longer held, lowers; on the other, the firing finger pushes the bolt, and the hammer rises with force and strikes the percussion match.

It will be understood that, as the hammer does not reach the match until at the end of its travel, the motion of the levers has already disengaged the arresting device of the torpedo, which becomes free in the tube before being submitted to the action of the gases that are to expel it.

As for the ignition, it is important that that should not take place until the breech is perfectly closed. If that is not the case, the fact is shown by the failure of the lever to reach the firing bolt.

Finally, after the torpedo has been fired, the burned match is removed from the vent by means of an extractor.

The ungearing is effected by means of a special battery formed of elements of the Lechanché type.

It now remains to be seen how the motive apparatus of the torpedo is set in motion at the proper moment. As well known, the self-moving torpedoes generally employed contain a motor actuated by compressed air inclosed in a small reservoir occupying the central part. Between this and the motor there is a valve for the introduction of air, and, for starting, it evidently suffices to open this valve. This operation is effected automatically when the torpedo starts. The valve, in fact, is maneuvered by a lever whose extremity, as soon as the torpedo is set in motion, meets with a finger projecting in the tube, and this finger or cam thus forms a stop and opens the valve, but cedes nevertheless to the stress and bends a spring, which repels it as soon as the torpedo has passed. It is important that this part shall be always in a perfect state, and this necessitates frequent inspection. For this reason, the constructor has endeavored to devise a method of closing which permits of a rapid mounting and which at the same time secures perfect tightness.

The cover of the cam box (Fig. 5) is easily raised by turning the winch of a screw of wide pitch whose nut forms part of a bronze arm capable of pivoting around an axis. A half turn of the winch suffices to disengage the cover, and, if the motion is continued, the winch carries along the arm and the cover itself, and thus allows the interior of the box to be seen. To close the box, the operation is evidently the reverse.

Such are the various constituent parts of the Canet torpedo discharge tubes.

We have above supposed that the discharge was effected through the pressure of powder gases. It was the French navy that first extolled this mode of firing, which Mr. Canet has definitively adopted.

At first sight, it might appear more convenient to employ the expansion of compressed air, which may be easily regulated in such a way as to strain the back of the torpedo less than the abrupt deflagration of a charge of powder does; but, under an apparent simplicity, the use of compressed air involves that of cumbersome and costly installations. To convince one's self of this, it is only necessary to glance at one of the powder and compressed air torpedo discharge tubes (Fig. 8) devised for the Russian navy, and constructed by the Societe des Forges et Chantiers de la Mediterrané. In addition to the compressed air reservoir placed under the tube, the latter is overloaded with pipes, valves, and cocks, that are accompanied with numerous causes of trouble. It is necessary, besides, to install a compression pump on board, and, although this is not a serious impediment for a large ship, the same is not the case for a small torpedo boat. The reservoirs themselves have to be of quite large capacity; if not, the pressure would abruptly lower therein, and it would take but one or two discharges to exhaust the supply of air. The tubes would then be out of service until the compressed air was renewed.

With the use of powder, all such troubles disappear, provided that it be surrounded with certain precautions, which, in the system under consideration, have been the object of a very attentive study.

If we add that the cost of the first establishment is reduced in a notable proportion, it will be understood why this mode of discharging torpedoes is tending to be substituted more and more for that by compressed air, both in France and foreign countries.

The cartridge used by Mr. Canet is a simple cake of special powder of peculiar form. It is placed in a chamber formed in the inner surface of the breech and separated from the torpedo by a small metallic disk, so that the ignited gases are all at once projected laterally toward the sides of the tube, and do not directly reach the helix and the rudder. Soiling of the mechanism in the rear is thus avoided. The weight of the charge varies, according to the size of the torpedo, from 6 to 10 ounces.

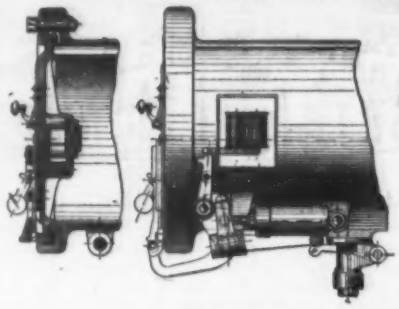


FIG. 4.—FIRING MECHANISM.

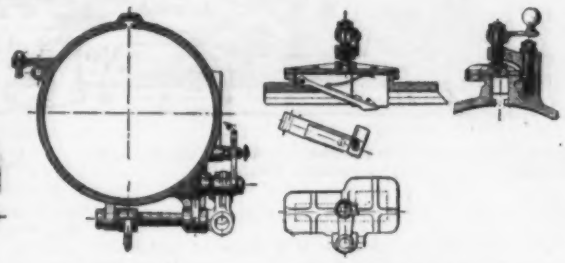


FIG. 5.—CAM BOX.

As we have said, the ignition of the charge is effected by a percussion match; but, in certain special cases, electric firing has been preserved. But, among other advantages, the percussion match presents that of never missing fire, this being something that is to be feared with electric matches if a contact be, by accident, badly established.

The torpedo discharge tubes can be fixed in an invariable manner to the ship that carries them, and, for direct pointing, it is the ship itself that has to be maneuvered. Such an arrangement, as we have above said, is admissible only on very small torpedo boats, which, so to speak, are but torpedo discharge tube carriages.

The tendency, which is every day more marked, is to place the torpedo tubes upon the deck of the vessel, so as to give them a wide range. In fact, there is no serious inconvenience in rising above the plane of the water. It is true that the tube is then entirely exposed; but the advantage of being able to fire crosswise while running at full speed along the enemy's ship is more valuable than the protection (which, moreover, is somewhat illusory) afforded by the plates of the deck. It is not impossible, moreover, to protect the tubes behind a light shield of iron plate fixed to their carriage. But, in torpedo boats, we are always estopped by the question of weight.

The carriage is capable of being variously combined. The following are two of the combinations devised by Mr. Canet for torpedo boats. In the first, the tube is mounted upon a true turntable fixed upon the deck (Fig. 7). It is necessary to be able to vary the inclination of the tube, not in order to modify the range, as with ordinary pieces of ordnance, but simply in order that the torpedo may reach the water at a proper distance from the vessel. It is likewise of utility to be able to change the inclination of the tube, in order to place it horizontally when the consumption of coal has modified the distribution of weight and changed the trim of the ship. This is a consideration which is of importance upon vessels of very small tonnage. In order to permit of this maneuver, the tube oscillates around a trunnion placed in front of the plate, while the back is lifted by means of a toothed arc actuated by an endless screw and a winch.

It might seem astonishing that this mechanism has been left free to the open air; in fact, the men whose duty it is to give the inclination would be much exposed if they had to effect this maneuver under the enemy's fire. But, in reality, things do not take place in this way. The upward pointing, which, in most cases, is done once for all, must, in all cases, be effected at the same time as the introduction of the torpedo, that is to say, out of the range of the enemy. The same is not the case with direct pointing, which it is necessary to be able to effect in the interior of the ship. To this effect, the platform is provided with a toothed arc actuated by a pinion whose vertical shaft runs through the deck as far as to the maneuvering chamber. It is likewise from the post of the torpedo boat's officer that the firing mechanism can be thrown into gear. For this, it suffices to establish an electric communication and to send a current through the electro-magnet that attracts the detent.

In most ships of recent construction, the post of observation is situated above the torpedo discharge tubes, which are themselves established under the deck. The officer has under his eyes a sighting apparatus by

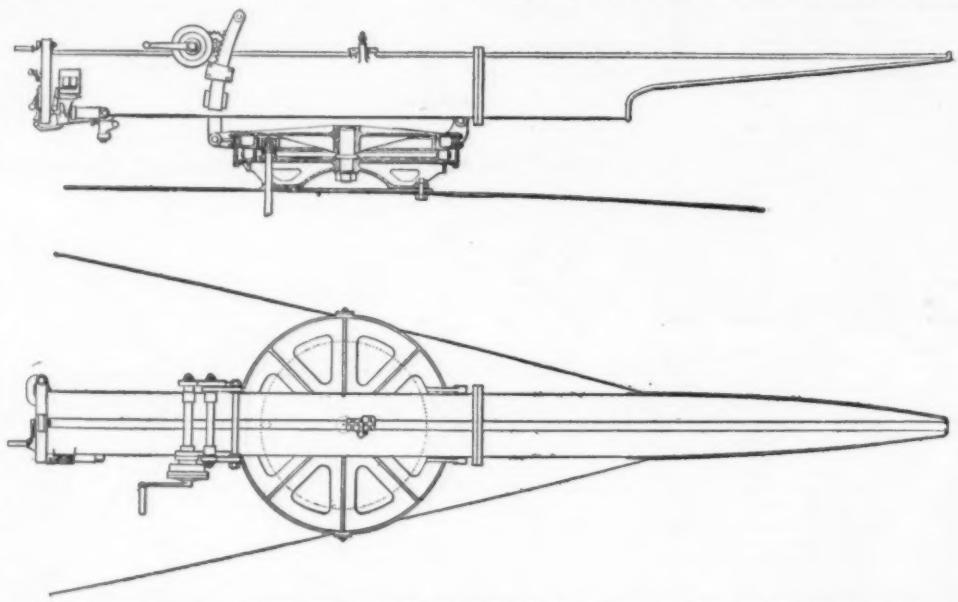


FIG. 6.—TORPEDO DISCHARGE TUBES INSTALLED UPON A POINTING PLATFORM.

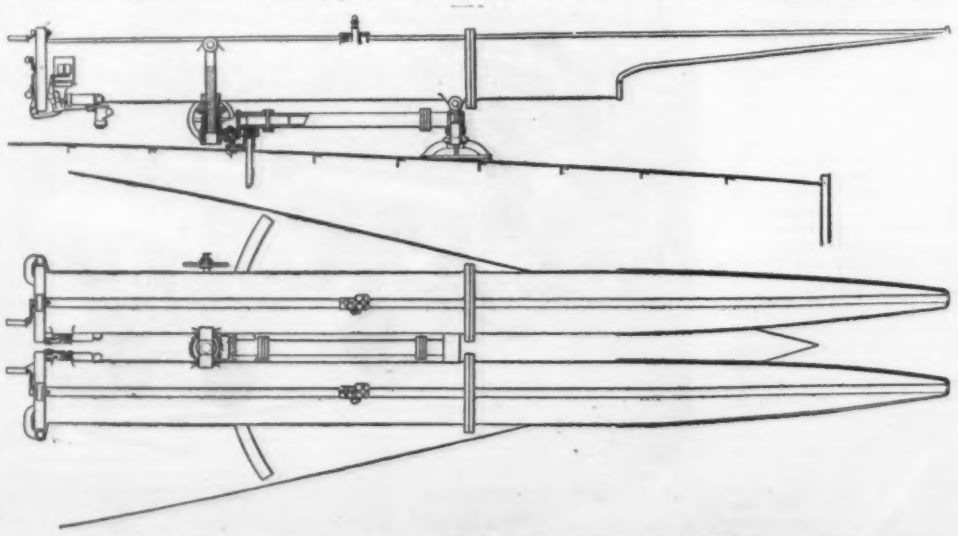


FIG. 7.—TORPEDO DISCHARGE TUBES IN PAIRS FOR TORPEDO BOATS.

means of which he can determine at every instant the conditions of pointing, which, with a torpedo of determinate velocity, make him sure of reaching a vessel situated at a known distance and of an estimated speed. Various devices permit the officer to point and fire, without any intermediate aid, at the precise moment that he judges opportune. A simple bell, solely, announces to him that the tube is loaded. Besides, a special bell indicates whether or not the battery is working properly.

Instead of the platform carriage, which, as a whole, is necessarily somewhat heavy, Mr. Canet has devised another and very simple arrangement (Fig. 10) in which the front of the tube is supported solely by a jointed pivot firmly bolted to the deck, while the back is supported by a carriage capable of moving laterally upon a circular track.

It remains to examine the case in which a torpedo tube is to be installed in the battery. It must then necessarily pass through the side planking, and, in order to reduce as much as possible the port through which it emerges, it is made to pivot around the center of this aperture in the maneuvers of pointing. This result is obtained by a very simple arrangement, which has the additional advantage of completely closing the porthole and rendering it tight. The front of the tube is provided with a flange cast in a piece with it, or a movable collar, according to circumstances, which bears against a ring surrounding the porthole and affixed to the woodwork. The flange and ring are assembled by means of a collar, either through the aid of bolts or a bayonet joint.

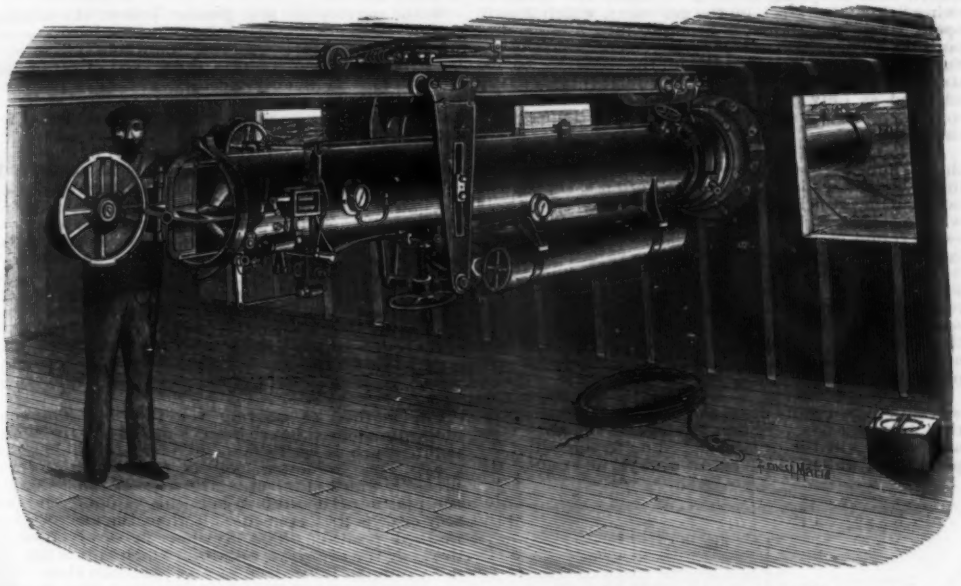


FIG. 8.—COMBINED POWDER AND COMPRESSED AIR TORPEDO DISCHARGE TUBES.

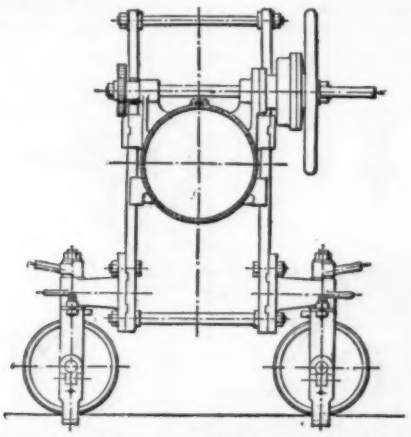


FIG. 9.—DECK CARRIAGE FOR TORPEDO DISCHARGE TUBES.

The tube being thus supported in front, it suffices to furnish it with a carriage rolling over a track and provided with various pointing mechanisms.

It is possible to give this entire system two different arrangements, according as the track is fixed upon the floor of the battery (Fig. 10) or to the beams overhead.

The form of the carriage varies according to the arrangement adopted.

When not in use the torpedo tubes can be removed from the ports (which are then closed) and arranged along the sides of the vessel, and the floor of the battery is then free from all obstacles.

On large ships, the tubes, as a general thing, are isolated. On torpedo boats, they are often established in pairs (Fig. 7), and, in such a case, their axes may be either parallel or divergent. The torpedoes are then fired either at very approximate intervals of time or simultaneously, in order that, if the object is missed, there may be a chance of reaching it with the other torpedo. Mr. Canet has applied this arrangement upon some torpedo boats destined for the Japanese government.

Yet the objection is made to this arrangement of divergent tubes that it renders pointing difficult, and it is generally preferred, when tubes in pairs are used, to place them parallel. The pointing is then done with great precision.

The officer who holds in hand the two circuit closers fires at intervals of a few seconds. The effect is then the same as with the divergent tubes, and if a torpedo misses the mark, there are many chances that the second will produce the desired effect.

It will be seen that the *materiel* that we have just described is positively of great simplicity and may be employed anywhere on land for the defense of passes, as well as upon any vessel, which may thus be converted into an improvised torpedo boat.

What especially characterizes the Canet tube is the simplicity and facility of the maneuvers. The men have only to tighten a spring and the officer can afterward, without any effort, and at the proper moment, discharge the torpedo.

It is a very important point, in order that the torpedo may carry just at the desired moment, that there shall be no stress to be exerted.

If the mechanism happens to be put out of service during a battle, the bolt may be acted upon by a lever; or, the percussion lock may be struck with a hammer. The use of the percussion match much diminishes those chances of missing fire that are to be apprehended with electric torpedoes. This system combines the advantages of electricity, as regards instantaneousness of firing, with those offered by the Abt percussion match, as regards certainty of operation. The closing of the breech is effected by a very simple maneuver of a winch. The compression of the packing is regular and energetic and affords a perfectly tight joint. The diameter of the port is as small as possible, owing to the fixed ring and the flange, but, despite the small aperture, the tubes have a very wide range in direct pointing.

The system of drawing the tube back into the battery permits the men to effect the loading under protection. This maneuver, moreover, is very easily performed.

The safety mechanism prevents premature firing; and, finally, all the maneuvers of upward and direct pointing and drawing back into the interior of the ship are executed with precision and without effort.

We shall not dwell upon the manner in which the torpedoes are handled, as this would be a little foreign to our subject, our intention having been to describe more especially the discharging apparatus. Let us recall the fact, however, that the torpedo, having been taken from the magazine, is placed in a metallic cradle which is hoisted by means of pulleys attached to the inner side of a carriage. This latter rolls over aerial tracks suspended under the beams and serves to carry the torpedo to the spot where it is needed.

Such are the general features that characterize the ballistics of the torpedo—that modern missile that has not had its last say. The projectile is still the main object of researches and improvements, but the discharging apparatus is none the less of very great importance. At all events, Mr. Canet has contributed in a large measure to the progress of these new apparatus, and we are happy to observe that, this time again, French industry has been able to devise types that are simple and ingenious enough to merit adoption by a large number of foreign powers, with whom the Canet tube has become regiementary, and even by our national navy. Our torpedo discharge tubes, in fact, have the same method of attachment to the side of the ship, a carriage of the same type, and a nearly identical system of firing.—*Le Génie Civil.*

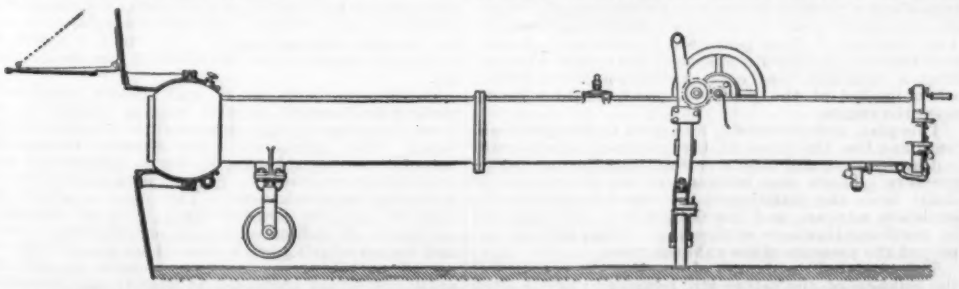


FIG. 10.—TORPEDO DISCHARGE TUBE FOR CRUISERS, MOUNTED ON DECK.

[Continued from SUPPLEMENT, No. 715, page 11418.]

ON GAS ENGINES.*

By EDWARD DELAMARR-DEBOUTTEVILLE, of Rouen.

THE SIMPLEX ENGINE.

THE Simplex engine (see Figs. 17, 18, and 19, and the engravings), invented by the author and M. Léon Malandin, was brought out in 1884. It is on the four-cycle plan of Beau de Rochas, and its main features are very much the same as the motor described by the inventor. It will be sufficient to examine in detail the various novelties and improvements which it offers, as compared with its predecessors, under the various heads of ignition, mixing of gases, governors, starting, working with petroleum vapor and with gas of poor quality.

Ignition.—During the preliminary studies and trials undertaken to determine the general arrangement of the projected new motor, practical experiments were made on all the known systems of ignition, and the conclusion was soon formed that the electric spark was the only satisfactory and economical method. But as none of the previous arrangements had given thoroughly successful results, the idea was formed of substituting for a single electric spark, produced by contact at a given moment, an uninterrupted stream of sparks, forming practically one continuous spark, produced in the thickness of the slide itself.

The great advantage of this arrangement was that the moment of ignition was determined by the edges of the ports, and at first it appeared strange that this device had not been hit upon by previous inventors; but when the practical difficulties of carrying out the new scheme were encountered, this was no longer a subject for wonder. It was found in practice that though the ignition from the sparks between the platinum points was controlled regularly enough so long as the slide was pressed tightly to the face, yet as soon as, from one cause or another, the compression inside forced the sliding surfaces apart, the inflammable mixture found its way to the spark prematurely, and the action of the crank was liable to be reversed. This fault was overcome by placing the porcelain insulator in the cover (Fig. 20), which made it impossible for the explosive mixture to reach the sparks before the slide had fairly opened communication with the combustion chamber. One more practical detail still remained to be achieved, viz., after each ignition to clear the oblique opening in the valve and the combustion chamber of the burnt gases, which would otherwise have combined with the fresh charge of explosive mixture, and impaired its deflagration. This difficulty was got over by forming a square hole between the combustion chamber and the slide face, so as to coincide with a horizontal groove in the slide, and thus at the proper moment to open up communication with the outer air. This is what happens: At the moment fixed for ignition, that is to say, when the oblique passage in the slide and the admission port of the cylinder come edge and edge, the compressed mixture drives out the burnt gases by the small hole in the combustion chamber, and is at the same instant ignited by the continuous stream of sparks between the platinum points. The time occupied by this expulsion is about $\frac{1}{125}$ of a second; but owing to the high compression of the explosive mixture, and its consequent velocity of flow, the clearance is perfect, and the instant of ignition mathematically punctual. The advantages of this new mode of ignition are considerable; the slide, which in other gas engines is the part of greatest nicety, becomes as simple as that of a steam engine, being merely a cast iron plate in one piece without any loose parts, pierced with two holes, one for the admission of the mixture, the other for its ignition. Its maintenance is easy and cheap, and with ordinary attention it will work for more than a year without any repairs. This is a great improvement over the equilibrium and flame-carrying slides, which require to be frequently faced up. By getting rid of this conveyed flame and of the gas burner, a considerable reduction is effected in the temperature of the valve chest, lubrication is facilitated, and incrustation is done away with.

The high igniting power of the spark allows of a much higher initial compression of the explosive mixture, with a corresponding economy in consumption of gas. This certainty of ignition and high igniting power have been of the greatest advantage in the application of the plan to poor gases. Particulars are hereafter given of some of the trials made with the Simplex engine, from which an idea can be formed of its economical advantages.

Gas Mixing.—The air and gas are mixed, not in the slide, as in the case with the Otto and other motors, but in an external receptacle fixed on the cover of the slide, the air entering from one side, and gas from the other, through a valve. After meeting and mixing, they are violently sucked in by the action of the slide through a channel at first circular, then conical, then rectangular, and are thus intimately combined into a homogeneous mixture. There is nothing particularly original about this arrangement, but it is simple, and the experience of more than four years has shown that it is completely successful.

Governors.—The two methods of regulating the speed adopted in previous motors were: (1) Entire admission or none—that is to say, the supply of gas was totally cut off for one or more strokes whenever any increase of speed occurred; and (2) proportional admission—that is to say, more or less gas, forming a more or less powerful explosive mixture, was admitted accordingly as the engine ran slower or faster. The second method at first sight appears the more rational, but entails certain inconveniences which have led to its rejection. The stronger or weaker mixture resulting from a proportional admission of gas is liable to

* Paper read before the Institution of Mechanical Engineers, at Paris, July 3, 1889.

become non-explosive, at one time because it is too rich, at another time because it is too poor. In either case no ignition takes place, and a charge of gas is expended to no purpose, and under certain conditions this waste may amount to a considerable proportion of the total consumption. For this reason some different arrangement, based on the principle of entire admission or none, was sought for.

Air Governor (Fig. 21).—This consists of a pump barrel mounted on the slide, and moving to and fro with it; in this barrel is a piston made perfectly tight by packing rings. The rod ofthis piston is attached to the cover of the slide, and consequently holds the piston stationary; it is fixed to the piston by means of two India rubber washers, which allow of a slight oblique motion to compensate for the movement of the cover against the slide. At the end of this pump barrel is mounted a micrometer screw with a conical point, which affords the means of throttling, in a greater or less degree, the square hole communicating with the outer air. Near this end of the air pump, on its side and at right angles to it, is placed another little cylinder communicating with it at its lower end. In this second cylinder moves freely a small piston, the rod of which carries at its end a steel knife edge. Between this knife edge and the piston is a spring, tending to keep the piston down on its seat; this piston is moved up and down by means of a semicircular nut. The outer end of the knife edge controls the valve for admitting the gas, when the small piston is down on its seat.

The action of this governor is as follows: If the engine is running at, say, 200 revolutions, the slide will be driven at a speed of 100 revolutions, and the large air pump will suck and force 100 cylinderfuls of air through the square hole at its extremity. Supposing that the micrometer screw is adjusted so as to allow only these 100 cylinderfuls of air to escape through the annular space partially closed by its conical point, then, so long as the normal speed of 200 revolutions is not exceeded, the small piston will remain on its seat, and the knife edge will encounter the gas admission valve and open it at each stroke to form the explosive mixture.

If from any accidental cause the speed of the engine is increased, and the slide makes, say, 101 strokes, the piston of the air pump will suck and force an extra cylinderful of air, and as this cannot escape by the square hole, it will raise the small piston and its knife edge, so as to miss the gas valve and fail to open it. No explosive mixture being formed, there will be a misfire, and the speed of the engine will be reduced. This governor is very sensitive, and will be very applicable to any future adaptations of the gas engine to boats or locomotives, as it will work equally well in any position, independent of level.

Pendulum Governor (Fig. 23).—For stationary engines, another form of governor is recommended, as it is cheaper and not liable to damage. This governor is based on the principle of the pendulum, but the method of its application is new, the essential novelty being that the pivot of the pendulum is absolutely fixed, and that the pendulum itself falls by its own weight alone, so that the time of its fall is invariably the same.

It is composed of two weights fixed on a rod, in the middle of which is a pivot. This pivot is carried in a bearing fixed on the cover of the slide. The heavier weight, of lenticular form, is naturally placed at the bottom. The lighter weight, which is above the bearing, is of spherical form, adjustable by means of two nuts threaded on the upper part of the stem. By raising or lowering this smaller weight, the lenticular weight, at the bottom of which is fixed a steel arm provided with a notch, is balanced to a greater or less extent. On the slide is fixed a stem, carrying an oscillating frame with two knife edges, one of which, at a given moment, encounters and opens a gas valve, while the other and smaller knife edge engages with the notch of the lenticular weight.

Besides being heavier, the larger knife edge is furnished with a spring, tending to cause the frame to swing below the stem of the gas valve, which it only opens when the frame is brought into a horizontal position. The action of this arrangement is as follows: Supposing the normal speed of the slide to be 100 strokes per minute, the spherical weight must be so adjusted as only partially to balance the lenticular weight; so that its rate of fall may synchronize with that speed.

At the moment of the back stroke of the slide, the small knife edge engages with the notch of the pendulum. Then the slide makes its forward stroke, and the notch, being still in gear, brings the pendulum to bear with all its weight against the small knife edge, the swing frame oscillates, and becomes horizontal. The larger knife edge encounters the gas valve, and opens it, and the explosive mixture is formed. Should the slide travel at a slightly accelerated speed, it will return in a shorter time than before: the small knife edge will miss the notch, as the pendulum will fall in the same time as before, and its weight will not bear on the swing frame, which will remain in an oblique position and fail to open the gas valve.

No explosive mixture will be formed, and the engine will slow down to its normal speed. It is evident that this governor is a very sensitive one, as the knife edge and notch will hit or miss according to the fall of the pendulum, which must occur always in exactly the same time. There is no wear of parts, and the speed is regulated by simply adjusting the upper or spherical weight, which can be done while the engine is running.

Various Modes of Starting.—For engines of small size, not exceeding 10 horse power, starting is a very easy matter; a turn of the flywheel draws a charge of the explosive mixture into the cylinder and compresses it, ignition takes place, and the engine starts at once. This statement refers, of course, to the Simplex type of engine, in which ignition is effected as easily at a slow as at a high speed; but with other types, starting is a much more difficult matter.

Up to 10 horse power one man can turn the flywheel and produce compression; beyond that size, and in proportion as the engines become larger, the number of men becomes a serious consideration, and for many years inventors have taxed their brains to discover some handy method of starting. A few of the more important of these schemes may be mentioned, but no good purpose would be served by describing them all. The simplest of these plans was to store up in a separate receiver, during the time that the engine was running, a sufficient charge of explosive mixture, which, when ignited at the proper moment, would serve to start the engine.

This plan, unfortunately, was open to two grave objections; the tightness of the retaining valves could not be insured, and after a certain time the gas lost its pressure. There was, besides, the risk of serious accidents from the bursting of the vessel containing the explosive mixture, and the danger from this cause led to the discontinuance of the plan. Other makers employed the pressure of the exhaust gases.

This obviated the danger of bursting the vessels, but the leakage of the valves still remained; and it often happened that, just when it was wanted, there was no pressure left in the cylinder, and starting was impossible. Compressed air, springs, and other devices of a more or less practical nature were tried and abandoned, and a small auxiliary motor was at length adopted as the only reliable plan. This system is incontestably effective, but it is expensive, and for engines of any considerable size it costs as much as a small additional engine, besides the singularity of employing one engine to start another.

With engines of still greater power, the auxiliary engine itself becomes so large as to need a second smaller one to start it, so that the whole system would be strongly suggestive of a show card of various sizes of engines. It is only recently, and after protracted research, that a satisfactory method of starting has been worked out; and it is the special method of ignition employed (Figs. 17, 18, and 19) which has rendered its adoption easy and its operation certain.

The arrangement for engines of 20 horse power and under will first be described, and its increased simplicity for engines of larger power will then be pointed out. For an engine of 16 horse power for example, a small gas pipe furnished with a three-way cock is fitted on the igniting apparatus; an admission passage for gas traverses the barrel, and a small hole of suitable section communicating with the outer air is pierced in this passage. An India rubber tube connects this gas pipe with the gas supply of the engine, and at the point of junction is fixed a small graduated cock (which may be called the gas cock), the degree of opening of which regulates the proportions of the explosive mixture.

The method of starting is as follows: The engine must previously have been stopped at the ignition point, which is easily done by means of the three-way cock. The induction coil is fitted with a contact breaker, which interrupts the flow of sparks between the platinum points. When this is done, the three-way cock is first opened and then the gas cock to the marked position. The flywheel is slowly turned to draw in the explosive mixture, which enters the cylinder through the seating of the porcelain stop. When the piston has made two-thirds of its stroke, the three-way cock and gas cock are closed. Then the plug of the large gas cock used when the engine is running is turned, and set at the position convenient for starting.

The flywheel is turned backward to compress the charge, the current switched on, the spark produced, the charge ignited, and the flywheel receives an impetus sufficient to start it. For motors of 20 horse power and under, it is necessary to compress the charge slightly (as just described), because the passive resistances are proportionately great; but with larger engines this is not necessary, and the operation is as follows: A small pet cock is fixed on the cylinder above the compression chamber, forming a communication between its interior and the outer air. The engine must be stopped, not at the point of ignition, but somewhat in advance, with the crank at an angle of 90°, which, as before described, is easily done by means of the three-way cock.

The piston has then made about half its stroke; the gas cock is opened to the marked position as before, as is also the three-way cock. As the gas is under slight pressure, it enters the cylinder through the seating, and draws in air with it by the small oblique hole. The explosive mixture thus formed gradually fills the space behind the piston, expelling the burnt gas by the cock at the top of the cylinder, which must be opened previously to that for the admission of the gas. In about a minute (for a 50 horse power engine) the cylinder is full of explosive gas, and the cock above the cylinder, the gas cock, and the three-way cock are then closed. As before, the large gas cock is opened to the starting position, the current switched on, the charge ignited, and sufficient impetus given to the flywheel to start the engine. By this method the large engines which have now been at work more than a year are started with great ease.

Working with Petroleum Vapor.—In France, where the duty on petroleum and its products is very heavy, its application to gas engines is, and must be, very limited; but in the provinces, and in districts where there are no gas works, a motive power certain in action and easy of application is a matter of considerable importance. An attempt was therefore made to improve on previous applications of this source of power, and in the last combination this attempt has been successful.

Previous methods, as is well known, consisted in passing air through or over volatile liquids, the surfaces of contact being increased in several different ways. The petroleum was allowed to percolate through porous substances, or was agitated by vanes to facilitate evaporation. These methods involved the following inconveniences: The liquids, which were used of very low density—from 0·650 to 0·700—were composed of various elements of different densities. and the air which passed over them was at first carbureted by taking up the more volatile constituents, until the liquid increased in density, and the constituents became more and more difficult of evaporation,

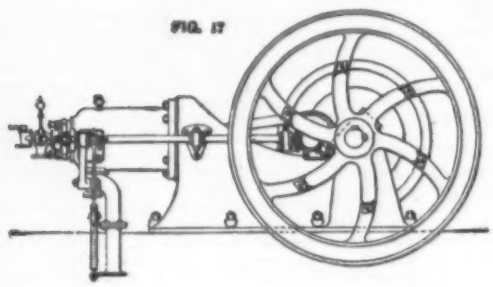


FIG. 17

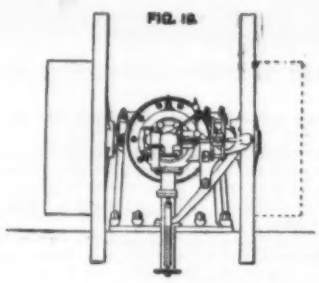


FIG. 18

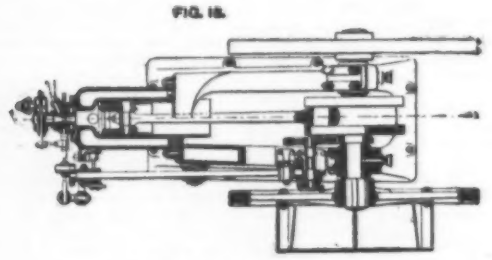


FIG. 19.

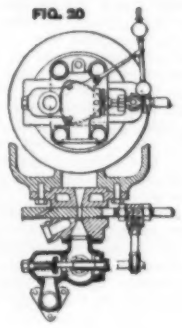


FIG. 20

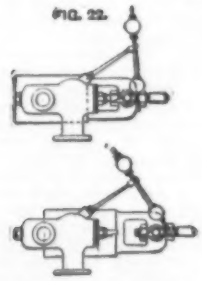


FIG. 22.

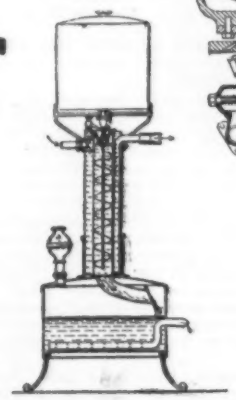


FIG. 23.

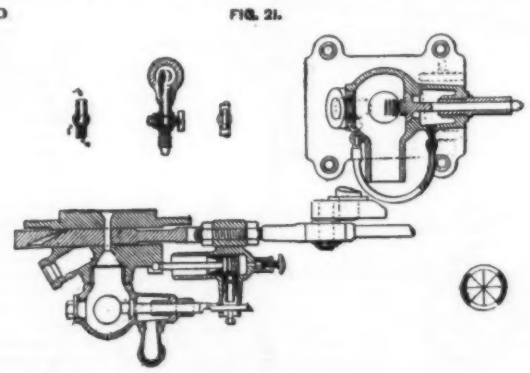


FIG. 21.

VARIOUS GAS ENGINES.

until at last a useless residuum was left, which had to be thrown away.

The engine, which worked well at first, gradually slowed down until it ceased to develop any motive power. In addition, the intense cold caused by the evaporation reduced the liquid to a condition unfavorable to the saturation of the air. This difficulty was surmounted by applying heat, either to the air before its introduction or to the liquid itself; but the gradual impoverishment of the liquid still remained. Another very serious defect accompanied all the systems employed.

During the distillation of the petroleum to obtain the light essences, a certain proportion of organic and mineral substances was carried over by the vapors given off, and these again were taken up in an impalpable form by the air during its contact with the liquid, and when subjected to the high temperatures produced in the slide and cylinder, formed a thick crust, which after a few days not only necessitated a thorough cleaning out, but also affected the moment of ignition by clogging the edges of the ports. This, of course, refers to the slide; but the result was equally objectionable, whether the above named process was adopted or whether the liquid was directly introduced into the cylinder by spray or injection pumps. A rapid incrustation resulted in either case.

Carbureter.—To get rid of these defects the arrangement shown in Fig. 23 was adopted. A receiver containing products of low density is placed immediately above a spiral horsehair brush, fixed in a jacketed chamber heated by the hot water from the motor, which neutralizes the refrigeration due to evaporation. Below this receiver is fixed a cock, with a graduated disk, by which the supply of the liquid is regulated according to the consumption of the engine. Close to this is another cock, admitting the hot water coming from the cooling jacket of the engine, and this water, at a temperature of about 50° C. (122° F.), mixes intimately with the petroleum vapor, which it carries along with it in its fall on to the brush, and by the time that it reaches the lower receiver the complete evaporation of the light essence has been effected. A safety valve, through which the gas is admitted to the motor, obviates any backward ignition.

It might be thought that the water would absorb a part of the light essence, and so cause a considerable loss; but this is not the case, and experience shows that the whole of the carbureted vapor is volatilized. The only constituents absorbed by the water are the mineral and vegetable substances before named, and all incrustation from this cause is completely prevented. After several months' working, the engine is in as good condition as on the first day. Moreover, there is no fear of the gradual impoverishment of the liquid, as the whole of the volatile constituents are evaporated from each part as it flows through; so that the working is always regular from beginning to end, and the power given off is always the same.

Engine Trials.—The Simplex engine has been tested with the following gases: Coal gas, Dowson gas, gas from the Lencauchez generators, petroleum vapor, and wood gas; and with all of them it works equally well. In spite of the high initial pressure to which the explosive mixture is subjected, the working is always easy and noiseless. This result is attained by determining the point of ignition, not at the dead point, as proposed by Beau de Rochas, but somewhat later, when the piston has already made part of its forward stroke.

At first sight, it might be supposed that this would entail a loss of power; but experience shows that, though the area of the diagram is diminished, the power registered by the friction brake is greater. Starting is also made easier by this method of working. The application of gas engines for driving dynamos has often led to fallacious results, and so far cannot be said to have been a success. It must be acknowledged that in most installations, especially those on the incandescent systems, to which it has been applied, the light has not been steady, but subject to fluctuations disagreeable and trying to the eyesight. On this account the use of gas engines for lighting purposes has been very restricted, although from the nature of things there should be a large field for their employment in that direction.

It has been sought to remedy this defect by employing a double cylinder engine and a countershaft, with flywheels on both countershaft and dynamo. The evil is thus diminished, but at the needless expense of higher first cost, increased space required, and a more complicated engine, as a better result may be obtained by simpler and cheaper means. Several months' experience at Mr. T. Powell's works in Rouen shows conclusively that a gas engine with a single cylinder, driving directly on to a dynamo placed as close as possible to the flywheel, gives a better result than the complicated arrangement above described. This statement can easily be practically demonstrated. All that is required, is first, to drive a dynamo in close proximity, trusting to the normal slip of the belt to minimize the fluctuations of speed, and then to drive it at a considerable distance.

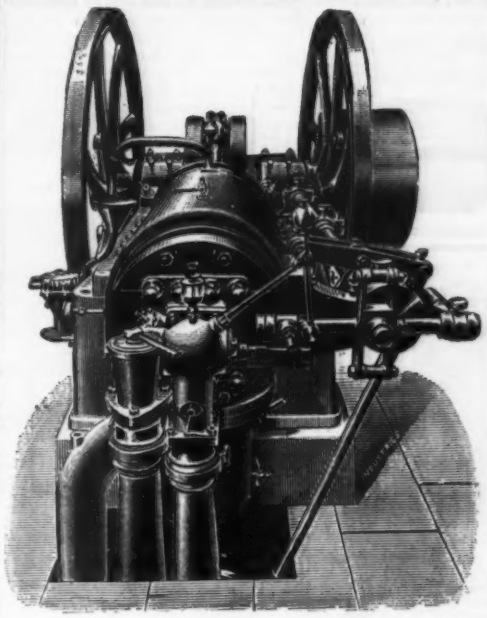


FIG. 2.—END ELEVATION.

A marked advantage, which may easily be explained, will be found to result from the first plan. With short belts the shock of the explosion is not communicated to the dynamo; but, on the other hand, by driving at a long distance, the shock increases the whipping of the belt, and transmits an amplified blow to the dynamo.

Some persons urge the objection that the slip of the belt under the first named conditions causes a loss of power; but this does not seem to be the case, as the number of lamps lighted per horse power per hour is the same at a short as at a long distance, as has been confirmed by experience. But even admitting that there is a slight waste of power, the loss is certainly less than that resulting from the use of a countershaft, which, as demonstrated by recent experiments in the United States, may amount in some cases to as much as 20 per cent. of the power transmitted.

Tests of Consumption.—Trials were carried out on the 7th and 8th November, 1885, by Dr. Aimé Witz, of Lille. Leading dimensions of the engine: Diameter of cylinder, 7⅞ in.; stroke, 15¾ in.; speed, 160 revolutions per minute. The effective work given off by the motor was measured by a Prony brake, the arrangement being that adopted by Messrs. Steward & Brooks. The ordinary lighting gas used contained about 5,400 calories per cubic meter (about 600 heat units per cubic foot) at constant volume; the Dowson gas, comparatively rich in carbonic oxide, about one-fourth of that quantity. Mean pressure of the town gas, 20 mm. (¾ in.) of water; of the Dowson gas, 55 mm. (2⅛ in.) 7th November, 1885: Duration of trial, 1 hour; effective horse power, 6·70; consumption of town gas per effective horse power per hour, 22·09 cub. ft.; reduced to 0° C. and 760 mm. barometer, or 32° F. and 30 in. barometer, consumption 21·55 cub. ft.; water per effective horse power per hour, 5·47 gallons; temperature, entering, 51° F., effluent, 135° F. Duration of trial, 2 hours; effective horse power, 8·67; consumption, 20·66 and 20·12 cub. ft.; water per effective horse power, per hour, 4·44 gallons; temperatures, 51° F. and 144° F. Duration of trial, 1 hour; horse power, 9·28; consumption, 21·23 and 20·73 cub. ft.; water, 4·38 gallons; temperatures, 50° F. and 172° F.

8th November, 1885: Dowson gas. Duration of trial, 2 hours; horse power, 7·12; consumption, 89·97 and 88·03 cub. ft.; water, 5·83 gallons; temperatures, 48° F. and 144° F. Duration of trial, 30 minutes; horse power, 3·61; consumption, 188·14 and 114·85 cub. ft. Duration of trial, 30 minutes; horse power, 5·26; consumption, 100·71 and 97·88 cub. ft.; consumption of oil (Moehring), 5·68 oz. per hour.

Other trials of the Simplex motor have given the following results: A 50 horse power engine, working with a load of 35 to 40 effective horse power, consumes daily, with a Dowson generator rather under-powered, 51 lb. of English anthracite coal per hour, equivalent to a consumption of from 1·148 lb. to 130 lb. per effective horse power, per hour, inclusive of everything. A 16 horse power engine, supplied with coal gas and working with a load of 12 effective horse power, uses 2,327 cub. ft. per day of ten hours, or 19·4 cub. ft. per effective horse power per hour.

These two engines are in constant work, and their consumption is calculated from the daily records kept for several months, and not from experiments. From the low consumption obtained by the use of poor gases a considerable development of the manufacture of large gas engines may safely be predicted; for their consumption is more economical than that of the best steam engines. This has now been conclusively proved.

In the foregoing rapid sketch, engines of types other than those of Lenoir and Beau de Rochas have been passed over, since the principles of their construction were not those from which the Simplex engine has been evolved. A more complete description of those principles would have required an extensive treatise. The author must acknowledge his obligations to the important works of Dr. Aimé Witz, whose theories have constantly guided his investigations; and also to the writings of Messrs. Dugald Clerk, R. Schöttler, and Gustave Richard, which are the most complete of all that have appeared upon this subject.

COMPOUND LOCOMOTIVES.

EXPERIENCE with the English locomotive which the Pennsylvania road brought over, and which has been undergoing tests for several months, according to a Pittsburg paper, will probably result in something valuable, though it is not probable that the English machine will ever be adopted as a whole. Of late it has been running from Long Branch to New York, and is becoming better liked every day for its improv-

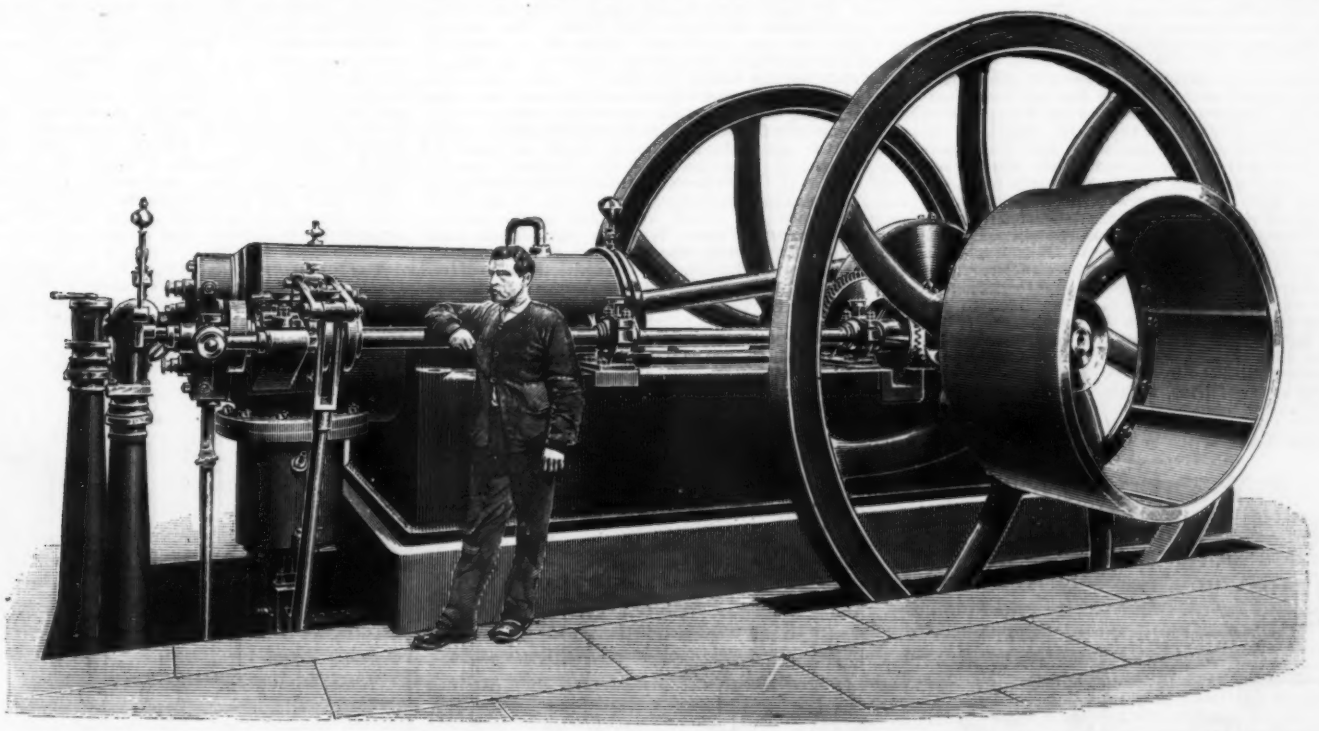


FIG. 1.—THE SIMPLEX GAS ENGINE—FRONT ELEVATION.

ing performances. The final test will soon be made. If these experiments prove, what is generally believed by engineers now, that the compound type will produce considerably more power at less cost than the styles of engines at present in use, then the compound system will be adopted at once by the Pennsylvania company and applied to all its locomotives as rapidly as possible. It is likely to be a year, however, before such a step is fully determined upon. One thing that has been discovered in the use of the Pennsylvania in regular service is that an English locomotive won't stand the wear and tear of American tracks. The en-

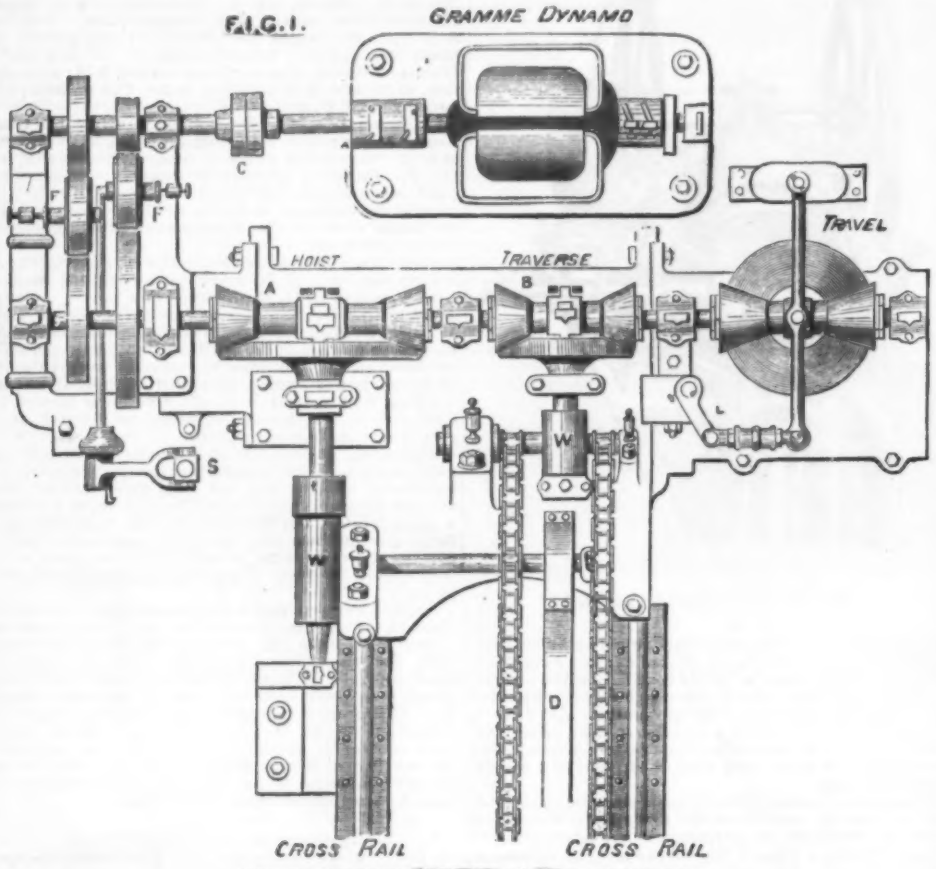
gine is too rigid and provided with too short springs to make an easy runner over our roads. The racking it gets on rough bits of track makes necessary frequent trips to the shops for trifling repairs.

THE TEN TON ELECTRIC TRAVELING CRANES AT THE PARIS EXHIBITION.

WITH the praiseworthy object of making all the working parts of the exhibition as modern and indicative of progress as possible, the administration decided to work the two 10 ton traveling cranes in the Palais des Machines by electric transmission. The practicability of this application of electricity has thus been visibly demonstrated, during the erection of heavy machinery in the hall, to many who up to the present had not been able to investigate its utility, the interest being greatly furthered by the fact that the cranes are worked on completely different systems both as regards the dynamos and motors in use and the mechanical gear for controlling the different movements.

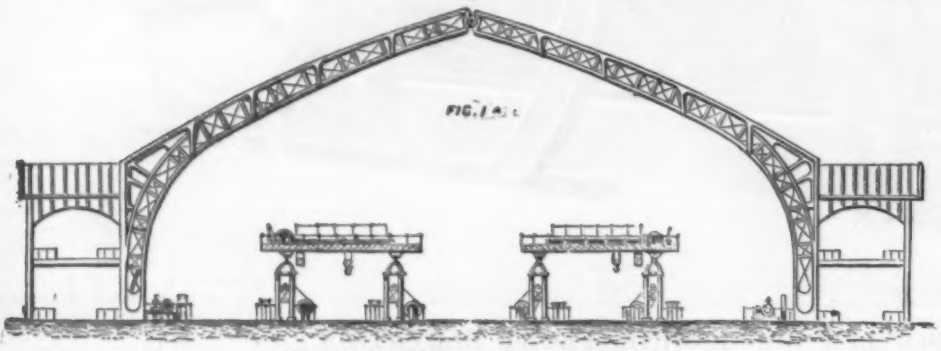
The position of the traveling cranes and supporting girders, with respect to the span of the hall, is indicated in Fig. 1 A. There are four lines of wrought iron girders continued throughout the entire length of the building, which are each supported on cast iron posts 20 ft. high, arranged in pairs as indicated. On the top of the girders, at a height of about 23 ft. from the ground, the rails for the travelers are laid, and some 6 ft. below these the main lines of shafting are supported by pendant brackets from the girders. The cranes each cover a span of 59 ft., and are indicated in the figure as they appear seen from the Labourdonnais or northeastern end of the hall. The installation of that on the right hand side has been intrusted to the engineering firm of Messrs. Bon & Lustremant, while the other, on the Ecole Militaire side, has been carried out by the firm of Messrs. Megy, Echeverria & Bazan, engineers, both houses being of Paris. Through the courtesy of these firms, we are able to give some particulars of their respective methods of working, and in the present article shall confine ourselves to that carried out by the first named firm.

A separate building erected in the Motive Power Court, outside the Machinery Hall, contains the generator plants for supplying both cranes with electrical power. The Gramme generator, supplying the Bon & Lustremant crane, is driven by belting direct off a 25 horse power Westinghouse engine running at 375 revolutions, and is identical in all respects with the motor fixed on the crane. The current is led from this station by insulated cables underground to the Suffren end of the hall, where the cables are jointed to the bare solid copper conductors, running along the length of the track. These two conductors rest on the top of porcelain reel insulators, fixed along each side of one of the main rails on the girders, as shown in Fig. 3; the last pair of insulators at the distant end being attached to the girder through a screw adjustment for taking up the slack. It was originally proposed to work with a silicium-bronze wire, owing to its greater mechanical resistance to wear; a copper-stranded cable was, however, first laid down, but, owing to the heavy continuous work to which the crane has been subjected since the opening of the exhibition, in the carrying of passengers and the consequent exceptional wear of the strands, this has now been replaced by a No. 5 B.W.G. solid copper conductor.



BON ET LUSTREMANT ELECTRIC CRANE MECHANISM.

The current is taken from the two lines of bare conductor by stout brass hooks hanging vertically from the under side of the body of the crane. The manner in which these are fixed and insulated by a wooden block will be seen in the figure, where it will also be observed that the hooks are fixed a little above the level of the porcelain reels, so that they not only pass clear of them, but lift up the conductors with a certain slight amount of strain sufficient to insure good contact. The electric generator and motor which are used for the working of this crane are of the improved Gramme type (Fig. 2) and have been manufactured and supplied, together with other electrical accessories, by the Compagnie Electrique, whose works are in the Avenue Philippe-Auguste, Paris. We hope, in a future number, when dealing with the Gramme central lighting station in the exhibition, to refer again more in detail to these machines. We may, however, draw attention *en passant* to the characteristic feature of this type of machine—viz., that the pole pieces, magnet cores, bed plate, and two bearing supports are cast in one piece. The motor, which was calculated to be capable of supplying 12 brake horse power, was, before leaving the works, subjected to tests, of which the results were as shown in the table. One French horse power being equivalent to 75 kilogrammeters per second, we have 900 exactly equal to 12 horse power, and a mean mechanical efficiency for the three tests of 75 per cent. This was calculated for the heaviest load the crane would be required to raise, viz., 10 tons, which it has frequently lifted and even sometimes exceeded.

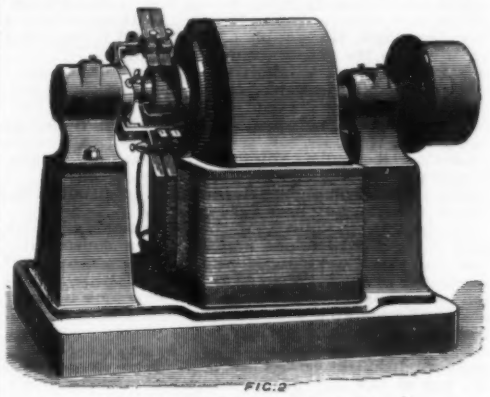


POSITION OF ELECTRIC TRAVELLING CRANES.

These details were kindly supplied us by Mons. Dehenne, director of the Compagnie Electrique. Now that passengers are carried, the weight is, of course, distributed; but allowing a moderate estimate of 11 stone per person, this adds to the weight of the crane by 8½ tons for 120 passengers, which is the average number. The net weight of the crane itself is 30 tons. During the performance of these journeys the motor runs at 730 revolutions, absorbing a mean current of 25 amperes. The length of track from one end of the hall to the other is about 320 m., or 1,050 ft., and this distance is traversed in 11 minutes, giving a speed of travel of 95½ ft. per minute. The current at starting is about 50 amperes, and the mean current during the run is from 25 to 27 amperes when moving toward the Suffren end, while it is a mean of 23 on the return trip. The motor and dynamo are both series-wound, and a resistance is fitted on the crane to adjust in the main circuit. A Desruelles & Chauvin voltmeter, capable of reading up to 350 volts, is fitted to the resistance board, together with an ammeter, as shown in Fig. 3.

Test.	Amperes.	Volts.	Speed.	Brake power, kilgms. per second.
I.	48	342	500	900
II.	40	275	600	904
III.	36	300	700	910

We may now discuss the mechanical gear for controlling the three different movements. (1) Travel, or the movement of the crane bodily along the track; (2) traverse, or the shifting of the burden across the span of the track; and (3) hoist, or raising and lowering the burden. By reference to the plan of the mechanism given in Fig. 1, it will be seen that the motor is coupled on to a short length of shaft carrying two pulleys of different diameter. In line with these are two paper-surface friction pulleys F, F, which are each carried by a forked lever at either end of a lever pivoted at P—Fig. 4. Again, in line with these pulleys are two different sized pulleys keyed on to the main power shaft. A forked lever keyed to the other end of the pivot spindle, P, carries a block between the fork arms, into which a vertical screw, S, works. It follows, therefore, that when the screw is turned the forked lever is raised or lowered, and either of the two friction wheels, F, F, made to bear down upon the two contiguous pulleys, so making mechanical connection between them. This movement is performed from the working platform by the hand wheel marked "speed," and by means of this gear the speed with which *any* of the three movements are accomplished can be altered in the ratio 1 : 2. That is, the power shaft can run at either 1½ times or 3 times the speed of the motor shaft. The slow speed is required in starting a heavy load, and the change in speed may be made when the movement is well under way, the gear being arranged that contact must be made by one or other of the friction pulleys.



GRAMME MOTOR, MODERN TYPE.

The power shaft lies parallel to the directon of the track, and is fitted with three nests of friction cones. Each pair of cones on the shaft is mounted on a sleeve in the ordinary way, which slides along a feather on the shaft, and can be shifted one way or the other by a forked lever acting at the center of the sleeve. The three intermediate cones which take off the power from one or other of each pair of cones are larger in diameter, so reducing again the speed, and are keyed to shafts running at right angles to the power shaft.

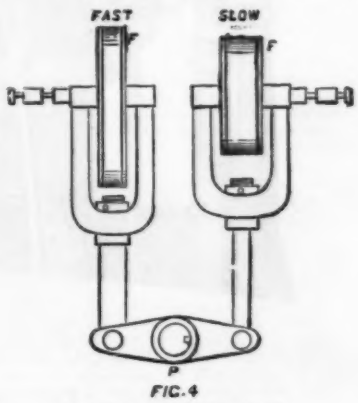


FIG. 4

DETAILS OF SPEED GEAR.

Again, the speed is further reduced and safety insured by worm gearing between the three shafts above mentioned, and the final shafts directly connected to the movements. In the figure, the nest gear on the left controls the hoist by the fork, A, and that in the center the traverse movement by the fork, B,

and that on the right the travel movement by the lever, L. In the first two the friction surfaces of the cones are of leather, while that of the cones for the travel movement is of paper, this having been found to work better. In the plan, the shafts for the two first movements are seen, being in the same plane, while that for the movement of travel is in a plane perpendicular to the plan, and, therefore, not seen. The latter delivers its power through worm gearing to a shaft fixed in bearings on the crane in a direction across the track, so that the propulsion movement of the crane is delivered through spur gearing to the wheels on each rail. The movement of traverse is effected by the two pitch chains passing round the shaft, as shown. The upper turn of each chain passes to the carriage, and is there fixed, while the under sides are continued across the crane, where they pass over pulleys, and return to the other side of the carriage, where they are fixed.

The hoist movement is effected by a chain fixed at the further end of the crane, which passes over a pulley

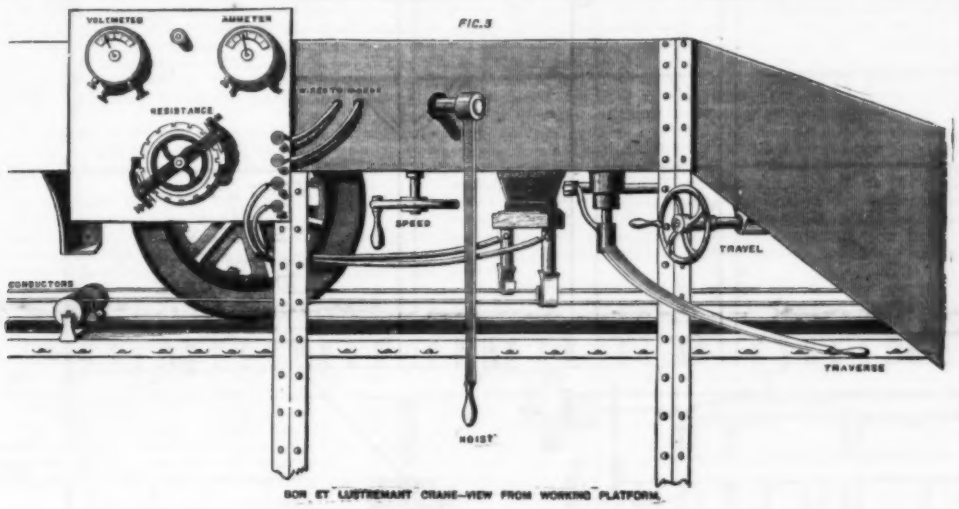


FIG. 3.

BON, ET LUSTREMANT CRANE—VIEW FROM WORKING PLATFORM.

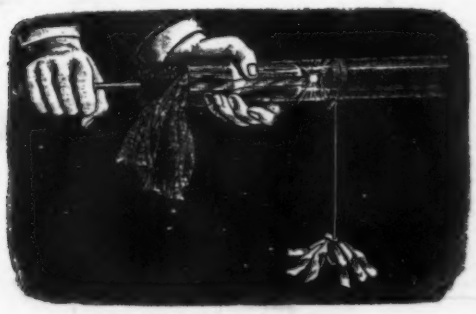
on the carriage, through the falling block, over a second pulley on the carriage, and then round the shaft supplying the power. The free end of the chain then passes up through an iron trough or casing, only sufficiently large to contain it, which is extended to a considerable distance horizontally, and contains the slack. A view of the interior of the working box below the crane on one side is given—Fig. 3—where the levers to control the movements are shown. These, together with the resistance commutator, which is also a switch for making and breaking circuit, are all within the reach of one man.

The mechanism is such as to permit of very gradual movements and the capability of working all three or any two of the movements together if required. While the erection of machinery in the hall was going on the crane was in continual use, and was found to be capable of very nice adjustment; for instance, the large Edison dynamo weighing about 11 tons was lifted and lowered accurately on to the toothed wheel gear mounted in three places on the bed plate for the purpose of stretching its driving belt in a vertical direction. Another piece of work was the fitting of a fly-wheel to its shaft.

Messrs. Bon & Lustremant have fitted up a 20 ton electric crane of 50 ft. span at the Canon Foundry of Bourges, where it has been running successfully for six years, also one within the last year at the workshops of the Chemin de Fer de l'Est, at Romilly, where it is at work in the open air, and used for lifting timber off wagons and stacking it. This is an 8 ton crane, its span being 104 ft., travel 650 ft., and height 30 ft.—*The Engineer.*

A SIMPLE ELECTRICAL APPARATUS.

ALTHOUGH the generation of frictional electricity, from a practical point of view, is not nearly as important as the generation of galvanic electricity—thanks



SIMPLE ELECTRICAL APPARATUS.

to the wonderful discoveries and inventions of the nineteenth century—still experiments of this kind are of great interest, not only to the learned who work in physical laboratories, but also to the educated laity. The apparatus shown in the accompanying cut and described in the "Elektronischen Echo" (Leipsic, O. Leiner), should, therefore, be of universal interest. By means of this apparatus an electric spark can be obtained in the simplest way imaginable, by any one, with very little expense of time or trouble. A strip of tin foil is fastened around the center of a common lamp chimney, and then a straight strip of the same material is pasted on the chimney from one end of the same to within a centimeter of the ring. Then a piece of silk is wrapped around a brush, to clean the chimney, and the interior of the chimney is rubbed briskly, but the fingers must not touch the tin foil. If this is done in the dark, each time that the brush is withdrawn from the chimney a bright electric spark will be seen to spring from one piece of tin foil to the other. Many other experiments of this kind can be tried with this simple apparatus. For example, it may be shown that poor conductors can be electrified by rubbing, further that good conductors can carry the electricity from an electrified body to one which has not been charged with electricity, and finally the power of bodies charged with the same kind of electricity to repel each other can be illustrated in the following manner: Bind a woolen thread (or better still, an iron or brass wire) over the tin foil ring, and on the end of this hang little strips of thin paper. If the interior of the chimney is now rubbed, the silk-covered brush being introduced at the opposite side to that in which it was formerly placed, the ring of tin foil is charged with electricity, which is conducted by the thread (or wire) to the strips of paper, which fly apart. As in all such experiments, the loss of electricity through dampness must be avoided. This can be done by thoroughly drying the brush, the silk, and the chimney at the fire, before trying the experiment.—*Illustrirte Zeitung.*

[ELECTRICAL REVIEW.]

THE DYNAMO.

OH, dynamo!
Who can tell thy mighty power?
Who can say if thy chief aim
Shall be to light the universe
Or rid the world of that unhappy class
Of human kind which goes by name
Of Murderer?

Who can say if thou canst claim
An E. M. F. of such degree
As shall be able, or to maim
Or bring to instantaneous death,
Thy victim?

Shalt thou aid, from depth below
The gentleman, to burn and scorch
All earthly sinners?
Or shall thy vast and untold strength
Be so directed that the human frame
A mummy shall become?

F. C. SCHNEIDER.

Johns Hopkins University, July 25, 1889.

THE ELECTROLYSIS OF DISTILLED WATER.

By M. E. DUTER.

THE author has employed in his researches distilled water contained in glass tubes with two limbs, which, even after the lapse of several months, did not communicate any alkalinity to the water. The electromotive power employed was considerable, always about 100 volts.

As electrodes were used: (1) an anode and a cathode of platinum; (2) anodes formed of very different metals, chiefly nickel, cobalt, iron, or copper, the cathode being still platinum; (3) an anode of platinum with a cathode of tin, of bismuth, of copper, of lead, of mercury, or of aluminum. In the first case, if the cathode is a fine wire while the anode is a broad plate, electrolysis yields for several days nothing but hydrogen. Afterward oxygen begins to appear at the positive pole, but its volume is always less than half the volume of the hydrogen liberated. Water thus submitted to electrolysis acquires a slightly acid reaction. In the second case the anodes are attacked, and during the first hours of the action they yield monoxides. At the positive pole there appears a jelly which is green with nickel, rose with cobalt, and blue with copper. After some hours the oxides take a darker color and pass into peroxides. If the electrolysis is let continue for some months, the oxide surrounding the positive pole is finally partially reduced. Thus nickelic oxide returned to the nickelous state and became green; cobaltic oxide, which was maroon, became a rose, and that of iron lost its rusty color and turned almost white. This transformation requires about two months; for ferric oxide it only begins after seven or eight months. It seems as if these deoxidations may be compared with those produced in hydrogen peroxide by oxygenated water. In the third case, where the negative electrode is constituted of a metal other than platinum, this metal, contrary to expectation, is generally oxidized. Tin yields stannic oxide with escape of hydrogen. Bismuth yields similar results. A negative electrode of copper is covered with a deposit which almost stops the passage of the current, even with an electromotive power of 120 volts. Lead at the negative pole is covered with gray tufts, which, if the current is interrupted, give rise to a plumbous oxide, which seems to flow from the electrode like a thin white paste. If the negative electrode is of mercury, the free surface of the metal covers itself with asperities of a pasty aspect, which liberate hydrogen and continue so to do for more than an hour after the cessation of the current.

Aluminum is energetically attacked at the negative pole, becoming transformed into alumina. After a time the metal loses its cohesion, splits up, and falls to the bottom of the vessel in the form of fine laminæ and of gray powder.

These experiments, and especially that with aluminum, render it probable that metallic hydrides are formed at the negative pole and are then destroyed by the water with formation of oxide and escape of hydrogen.—*Comptes Rendus* (cix., p. 108); *Chem. News.*

PROTECTIVE PAINTS.

AN interesting series of experiments have recently been carried out by the Dutch State Railways, for the purpose of ascertaining exactly the relative resistance of various pigments to atmospheric changes and to the corrosive action of sea water. The results have proved that the red lead paints are less affected by atmospheric influence than those which are composed of the brown oxides of iron, on account of their adhering more closely to the metal, and of their possession of great elasticity. It was also discovered that any sort of paint afforded an increased protection if the plates were pickeled in hydrochloric acid before its application. The prevention of corrosion by salt water was found to be possible by the admixture of the oxide of some electro-positive metal, such as caustic lime and soda; but the efficiency of such a covering diminished when its alkaline properties had been neutralized by the absorption of carbonic acid. Magnesia, however, was proved to be the most serviceable, seeing that it does not absorb carbonic acid; and not only does it protect the iron from galvanic action, but it also does not affect the anti-fouling qualities of the paint.

FUSIBLE PLUGS.

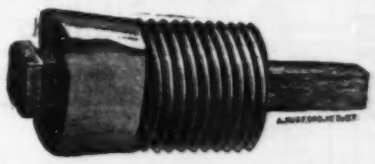
THE fusible plug is one of the most abused appliances to be met with around boiler rooms. It is so small, and in such an out-of-the-way position, that there is great temptation to let it take care of itself. Again, it is so seldom heard from that a fireman who is not very watchful is liable to forget about it. Yet when it is properly cared for, the fusible plug is a most important safeguard.

In the event of an explosion, too, it often furnishes valuable evidence concerning the immediate cause of the explosion. Thus, after the disastrous explosion at the Park Central Hotel in this city, described and illustrated in the March *Locomotive*, the fusible plug was found intact; and by placing it in a retort and carefully ascertaining the melting point of the filling, it was easily shown that at the time of the explosion the water in the boiler was several inches over the tubes. That is, direct proof was obtained that the water in the boiler was not lower than it should have been.

The "fusible" plug illustrated in this number of the *Locomotive* was found in a boiler in the South. The water in this boiler got low one day, and of course the fusible filling melted out and gave the alarm. The owner not having time to have it refilled, and not having another one on hand, drove a nail into it and went ahead as usual until the water got low a second time; when as the nail was not any more fusible than the boiler, both got hot at the same time. Fortunately this caused such a leak around the nail that the escape of steam relieved the pressure somewhat, and the repairs cost only about seventy-five dollars. The boiler was 42 inches in diameter and eight feet long, with an internal flue used as a fire box. The chances are that the owner will not drive any more nails into fusible plugs.

We remember another instance, in which the fireman had driven an iron rivet into the plug in a similar manner. When we remonstrated with him, he answered: "By gar, she do be melting out all the time." We told him if he would be more watchful of his water line that would not happen, but he insisted that the water had never been low since he had been fireman.

In Massachusetts the law concerning safety plugs reads as follows: "No person shall manufacture, set up, use or cause to be used, a steam boiler, unless it is provided with a fusible safety plug, made of lead or some other equally fusible material, and of a diameter of not less than one-half an inch, placed in the roof of the fire box, when a fire box is used, and in all cases in a part of the boiler fully exposed to the action of the fire, and as near the top of the water line as any part of the fire surface of the boiler. . . . Whoever without just and proper cause removes from a boiler the safety plug thereof, or substitutes therefor any material more capable of resisting the action of the fire than the plug so removed, shall be punished by fine not exceeding one thousand dollars. Whoever manufactures, sets up, or



knowingly uses or causes to be used for six consecutive days a steam boiler unprovided with a safety fusible plug . . . shall be punished by fine not exceeding one thousand dollars." And it seems to us that it would be wise to have similar laws in all the States.

When fusible alloys are used for filling safety plugs, it is found that their melting point is often considerably raised by long exposure to the heat. The exact cause of this rise in the melting point does not appear to be clearly known. It has been suggested that the metals composing the alloy are gradually separated or crystallized out from one another by the prolonged action of heat. However this may be, it is certain that pure Banca tin is a much more reliable material to use for filling. As tin is an element, its melting point remains constant, and it is low enough—420° Fah.—to adapt it perfectly for use in fusible plugs.

In order to prevent delay, in case a plug should melt out, all owners of boilers should see to it that extra ones are constantly kept on hand so that they can be put in place at short notice.—*The Locomotive.*

DRYING PLANT FOR WET FEED.

By S. E. WORRELL.

THIS plant is designed to be built in connection with starch factories, breweries, etc., having a surplus of live or waste steam and power. Therefore no boilers or motive power are shown.

The building, 60 ft. long by 34 ft. wide and 36 ft. high, is of composite construction. The first story is built of brick, and the second story, used both for cooling and storage purposes, of wood with solid plank walls clamped together by lateral and longitudinal bolts. This arrangement, copied from grain elevators, is the most substantial and economical for bulk storage. The designer's purpose is to secure the maximum capacity and durability at the minimum expense and space. Therefore, no display is attempted. All the heavy machinery is supported on the ground floor, and the dried product of moderate bulk weight. Consequently, the structure is of comparatively light design.

The daily drying capacity is from 1,500 to 2,000 bushels of dried feed, depending upon the percentage of moisture to be evaporated.

The bulk storage capacity is 25,000 bushels, and vacant space is left for filter presses or grinding mills if required.

The five large machines are the writer's latest improved No. 1 steam driers—consisting essentially of a double-walled cylinder of boiler plate, through which the heating medium circulates, inclosed in a wooden jacket with an intervening space for heating the air current. The latter has a positive circulation and is the important factor in the designer's different evaporating apparatus. In the interior of the iron cylinder is a rotating agitator for creating a constant commotion of the drying material. While in this separated condition the hot air is drawn through it and rapidly removes the moisture in the form of vapor.

These machines are adapted for handling very difficult substances—one has recently been supplied to an Arizona gold mining company for drying sulphate of iron, or copperas, used in their reduction works. This chemical contains 25 per cent. of moisture and melts at 210° Fah.

Each drier is supplied with a special feed press for expressing a portion of the liquor contained in very wet products. These squeezers are fed by the spiral conveyer, F, which brings the damp stuff from the adjoining factory. A similar conveyer, under the floor at the back end of the machines, carries the dried feed to the foot of the bucket elevator located near the middle of the building. This elevator has a double discharge into the top right and left hand conveyer, the bottom of which is perforated to permit the warm product to fall in numerous small streams, so as to be thoroughly cooled before bulking.

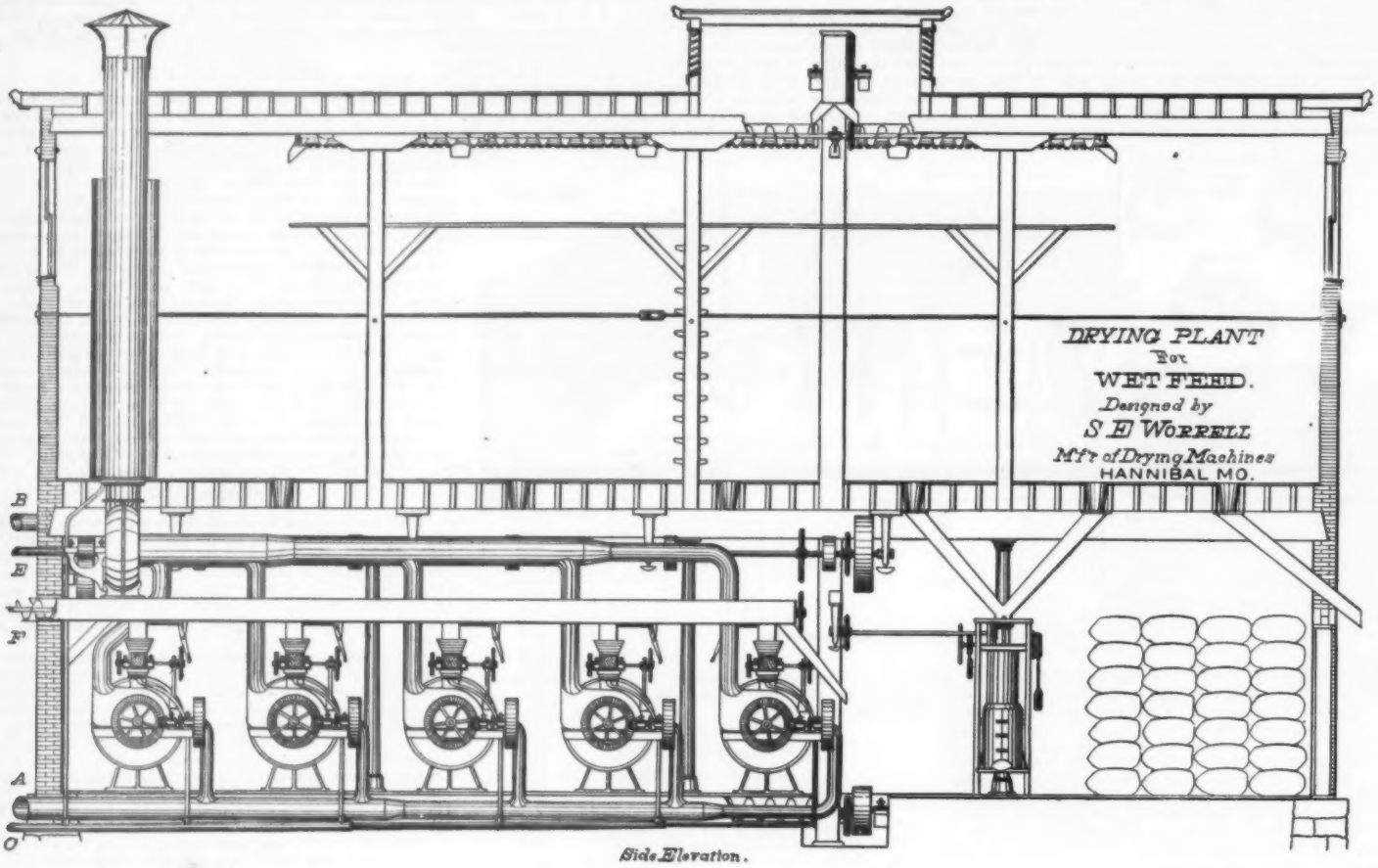
This conveyer and the floor below are provided with gate spouts for shifting the dried feed to any part of the building. To give sufficient ventilation to the storage room the attic is liberally supplied with slat windows and ample openings are provided under the roof projections on all sides of the building.

The positive air circulation, mentioned above, is created by the large blower, clearly represented in both plans, the exhaust of which is connected to each drying machine. All the moist vapor is discharged through the upright iron stack, which is surrounded by a shield to prevent heating of the bulked product.

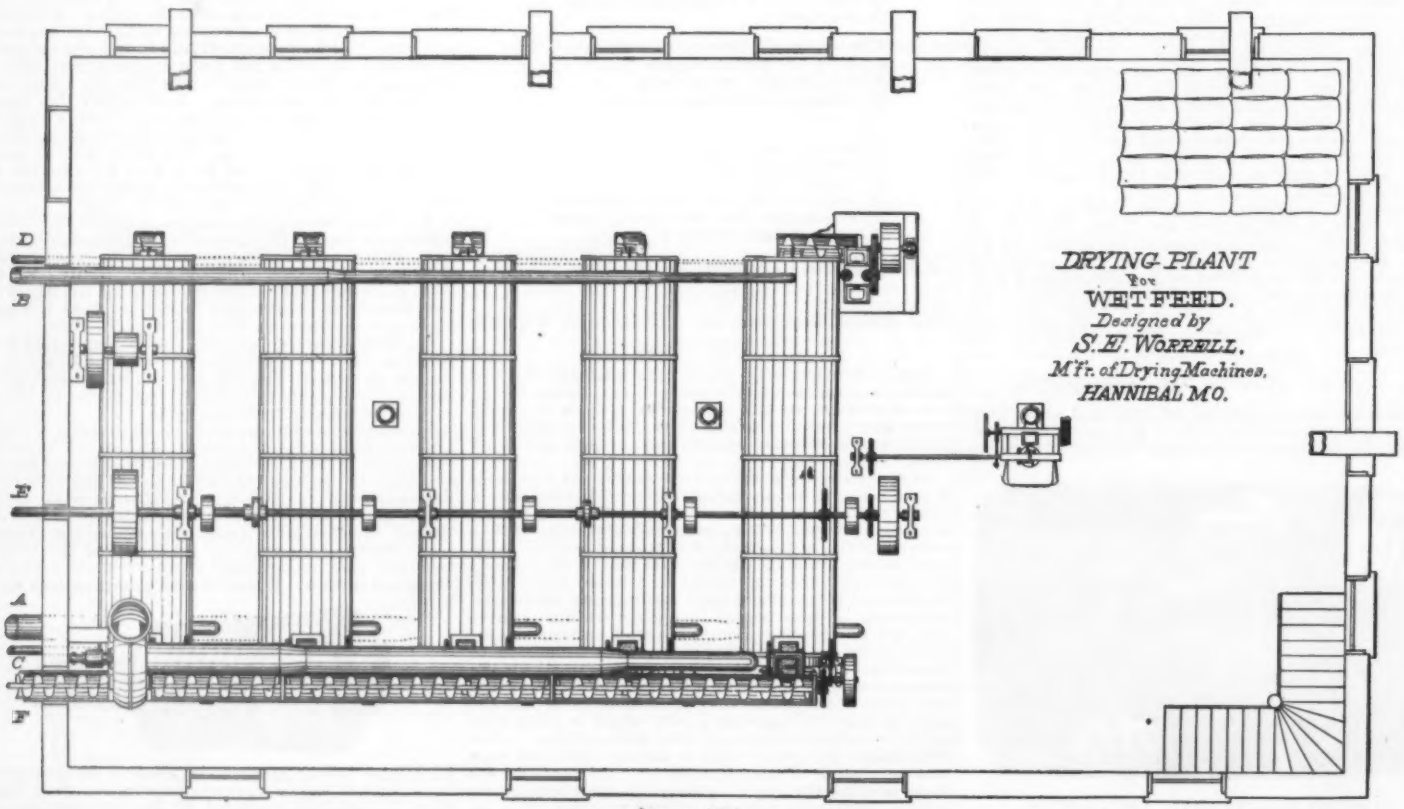
A represents the pipe for supplying the driers with waste or escape steam (a much smaller tube will answer where *live* steam is used) and B is the escape pipe. C and D are draining tubes for respectively carrying off the expressed and condensed waters. The vapor stack is connected with the former.

Motive power is transmitted to the whole apparatus through the single main shaft, E. The connecting leather and chain belting is omitted to simplify the views.

The improved feed sacker shown is of ample capacity to pack in a condensed form the entire product,



Side Elevation.



Ground Plan.

At the right side of the packer is represented a pile of sacked feed.

The numerous wall spouts are provided for discharging the product, in bulk, into either wagons or cars.

It will be noticed that the whole operation is continuous, requiring but little manual labor, and where waste steam is utilized for the heating agent, the process is very economical.

A SYSTEM OF MARKING PATTERNS, TRIED IN THE SHOP—WITH SOME REMARKS UPON ECONOMY AS VIEWED IN THE PATTERN.

By A. J. FRITH, Member of the Engineers' Club of St. Louis.

THE following system of marking has been found so useful, that while it may not be especially novel, it is believed that it will be of interest to many. We are all aware of the great confusion that arises in the care of patterns, the difficulty of keeping the small parts of various machines to themselves, the perplexity in gathering every essential core box, etc., when old patterns are to be used, and the dependence on the special knowledge of one man when any particular casting is desired.

The desirable points in a system of marking patterns, to lessen this annoyance, were considered to be:

1. That there should be as little clerical labor as possible.

2. That a special familiarity with the machine should not be requisite when a casting is desired.

3. That one could feel assured when patterns go to or are returned from the foundry, that no loose pieces nor core boxes are missing, and do this without consulting unhandy records.

4. When patterns or parts of patterns become mixed together, which seems unavoidable, that any piece, no matter how insignificant, can be at once distinguished and sorted out by any careful employe.

To insure complete control over our patterns, it is first necessary that they should be marked and a list taken. This system was begun in the draughting room, where the drawing of each casting was given and marked with a consecutive number—all parts of one machine having a characteristic symbol.

Then in a small book these were recorded as follows:

THIRTEEN-INCH SLOTTER. SYMBOL S.

Consecutive number.	Sketch.	Name.	No. of pattern.	No. of loose pieces.	No. of core boxes.
1	Roughly made sketches of each pattern.	Frame.	1	8	7
2		Ram.	1	5	2
3		Slide for ram.	1	3	2
4		Gibs for ram.	2	–	–
5		Quick return.	1	1	1

This record is kept in pencil to allow changes up to date to be easily made.

The first column contains the consecutive number of each pattern. The second column, a roughly made sketch of each pattern, which greatly facilitates the finding of a piece needed, as the description in the third column is necessarily brief. The fourth, fifth, and sixth columns give the number of patterns to each part, the number of loose pieces, and the number of core boxes.

This may look a little complicated, but it only needs a little attention once, and our clerical labor is finished. Whenever after the pattern or any part is needed, whether it is known by number, by name, or only by general appearance, this list furnishes complete data for identification of all its parts.

Upon each pattern, before it is varnished, is stenciled a legend, thus, for the "Slide of the Ram:"

S. No. 3.
3 pieces A. B. C.
2 Core Boxes. Z. X.

Being varnished, this record is indelible and always present Metal numbers, S. 3, are added, that the symbol may appear on the casting. The corresponding loose piece is stenciled S. 3, piece A., or the core box, S. 3, core box X., etc., and so for all the other patterns, pieces, etc. Hence, wherever the pattern is, the record of all its corresponding parts is at hand for reference, and is intelligible to any one, or any piece, no matter how trivial, has an indelible mark that enables us to place it at once.

It has been suggested that by not marking pieces and core boxes by letters a, b, c, etc., the legend would be rendered much simpler, the legend above becoming merely

S. No. 3.
3 pieces, 2 core boxes,

each piece and box being simply stenciled S. 3, showing thereby that it belongs to pattern No. 3 of machine S.; that is, the 13-inch slotter.

This, however, requires the counting of the number of pieces, etc., and the identification is less certain, while if any core box is to be used for more than one pattern, the necessary instructions become somewhat uncertain.

It has been customary also to stencil the word "Face," not on all the planed surfaces, but on those that particularly need to be clean, that the foundry may be reminded where to be more careful. Naturally, the use of 2 S, 3 S, etc., for other sizes of slotter, or L, 2 L, etc., for different build of lathe, etc., will occur to the user. It is believed that a little attention given to some such system as this, especially for standard machines, gives a record of easy reference and a means of bringing order out of the chaos common in too many pattern lofts.

In regard to the economy of manufacture, as viewed in the pattern, there are so many facts and circumstances entering the problem that I shall touch upon but a few instances that point the direction in which to turn our attention.

1. The economy in the pattern itself, that is, its cost in labor and material; this economy should be governed by the number of castings we expect to obtain from it, it being evident that the thought and labor justified and economical in the production of a number of machines would be extravagance where but a few castings are to be produced.

In the latter case the original cost of the pattern is a sensible percentage of the total value of the product, and to reduce this as much as possible, we should confine our designs to straight lines and flat surfaces, curves and warped bodies being expensive in both time and labor. The pattern can be roughly made, with little provision for warping, as few ribs and fillets as possible are desirable, with few and plain cores, it being generally economy to sacrifice appearance, to be lavish in metal, and ignore many points, though not those of efficiency and stiffness in the final machine.

When the pattern, however, is expected to be duplicated many times, true economy of construction calls for much thought and care, and frequently very elaborate and costly patterns are the cheapest in the end. It pays to build up rings and gear wheels of many parts, that time may not warp them nor rough usage so dislocate faces and parts that the resulting castings are scanty in metal in one part or require excessive finish in another. We should now consider closely how the casting is to be handled, in finishing and in erecting, cutting down turned and planed surfaces to the smallest allowable limit, and not be afraid of using small and numerous cores where your judgment bids you. Excessive amounts of finish on bright surfaces can frequently be curtailed; and in other cases where cored round holes are horizontal, and the core therefore liable to shift or rise in the molten metal, we may properly add an extra amount of metal, that the requisite size may be assured, despite accidents.

It is frequently advisable where cored holes are in line, one with the other, to use one long core passing through both bearings rather than two smaller ones, as we are thus assured that the holes in the resulting castings will be in line, thus saving the cost of careful setting of the piece and the long and difficult boring that would be necessary to obtain the required dimensions.

In other cases, such as in long holes, where it is not necessary that the running shaft should bear the entire length, it is customary to enlarge our core between the bearings, so that we may only be at the expense of finishing the bearings, and not the entire distance, but judgment must be displayed in the use of such devices, for if, as in this instance, the thickness of metal at our command does not allow us to make this recess a very decided one, and the core should shift somewhat in the casting, there is no economy, for we may be chagrined to find that a large part of our boring is just in the rough surface of the recess, and the expense in obtaining a true hole is perhaps more than doubled. If I had the space, I could cite many similar instances, emphasizing the necessity of care in the use of our little schemes for economy, and of the study of the various operations, methods of handling, and final erection through which the casting is to pass, where the cost of the finished product is dependent on the pattern, but I will merely touch on a point in which much uncertainty is frequently displayed.

Castings are frequently made very thin and light, with a view to save the cost of the unnecessary metal, which is good economy; but it is not considered that the thinner we make our casting, the more difficult it is to prevent it from being badly sprung in cooling, in which case we will have saved a few pounds of cheap iron and necessitated several days of costly machine work to finish it. In all this, I do not mean to decry the effort to save metal by making our castings light, but only to impress the necessity of considering well the effect of each effort to do so.

We have all heard that to avoid this trouble of warped castings it is better to have all parts of a uniform thickness, with heavy fillets between ribs and surfaces; but this rule is not one of rigid application, though that of its meaning, uniform cooling, is true, as far as my experience extends. For instance, if we have to cast a flat surface, stiffened by deep ribbing, we will find that if the surface is to be planed that it will be cast face down, that the planed surface may be freed from floating dirt; this brings the ribs uppermost, and if to economize metal the ribs be made lighter than the face, they will cool first, and if the resulting casting be of any length, it may be bowed a half an inch, requiring much extra time to true up the face; even if the ribs be made of the same thickness as the face, they will still cool first and bow the casting, since they are nearer the surface and removed from the greater body of hot metal. In cases similar to this, we have obtained the most economical results by cutting down the thickness of the face or body of the casting and making the ribs considerably the thicker, that they may be retarded in solidifying until the metal deeper in sand has begun to stiffen, while $\frac{1}{8}$ inch saved over the larger face amounted to more than $\frac{3}{8}$ inch taken from the ribs. We believe that the same idea can be frequently applied with marked economy in metal and labor.

These instances are to show that, when viewing the economy of manufacture in the pattern, the best economy is obtained by keeping well in mind the subsequent manipulations and probable errors in the foundry, that while we make use of careful coring, recessing of core holes and light castings and ribs, we may not enhance the final cost by unwise economy.

One word more I would like to add, as to the necessity of accuracy and frequent checking of measurements, as there is nothing more frequent nor more exasperating than errors in the dimensions of patterns. It is not enough to carefully check the sizes on the drawing, but the pattern should be viewed during construction, in imagination, as fitting in the finished machine, thus guiding us to detect possible interferences, and often to discover that our patterns, while correct in dimensions, are actually reversed or upside down; and whenever possible, all patterns of parts fitting one into another should be kept back from the foundry until all are finished, so that they can be placed together as they belong, and the dimensions checked independently of the design. Only by unremitting care can we thus, in complicated machinery, obviate the occurrence of annoying errors.—*Jour. Assoc. of Engineering Societies.*

SILICON IN PIG IRON.

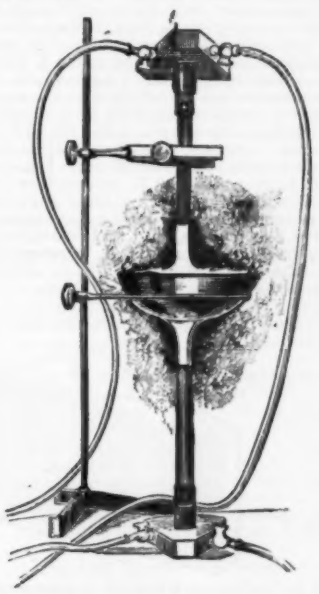
By CLEMENS JONES.

IN the "direct process" of making steel, and very frequently when making foundry iron, it is necessary to determine silicon in the iron in a few minutes. To do this within the time limit with reasonable accuracy has been found a task by no means simple.

By Ford's method, silicon can be determined in twelve minutes after taking the sample. There are several modifications of this method, but each has the objection that during evaporation a loss is caused by spattering.

The endeavor to overcome this defect led to experiments on shortening the time by merely hastening the *modus operandi* of a standard method. Dr. Drown's admirable method was selected, and by the use of the device figured in the cut it was found that evaporation of 50 c. c. of nitrosulphuric acid could be done in three minutes with complete dehydration of the silica, and very little loss, as evaporation is not carried to dryness. Moreover, the disappearance of nitric acid is marked by a strongly tinged flame reaction.

A platinum dish of 150 c. c. capacity is used. 1 grm. of borings is transferred to this, 50 c. c. nitrosulphuric acid added, and the dish is then placed between the flames from two blast lamps. The arrangement of the lamps calls for no description; a slight adjustment of the flames, in both distance apart and intensity, is all that is required before the right effects are secured. This being done, however, the arrangement becomes a fixture. The downward flame should be a trifle stronger than the upward one. In fact, wire gauze beneath the dish gives better results by distributing the heat evenly. A Bunsen burner may be substituted for the lower lamp. Violent ebullition is prevented by the current of heat and air upon the surface of the boiling liquid, so that by giving the dish a circular motion with a pair of tongs when nearing final expulsion of nitric acid, the fumes of sulphuric acid are quickly obtained, accompanied by a sharp play of reddish yellow color of the impinging flame. When finished, the sulphate of iron is in a thick, semi-pasty state, into which hot water can be poured at once. Again placed between the flames, this is speedily dissolved and is ready for subsequent treatment.



I may add that gasolene gas was employed in the experiments.

A few comparative results are given below. The irons chosen were 1 low, 2 medium, and 1 high silicon iron. The slightly higher results by rapid evaporation are due to undissolved ferric oxide formed by the intense heat.

No. 2602. Regular method (Dr. Drown's). Silicon = 0·445 per cent. Rapid evaporation.

	C. c. acid.	Time for evaporation.	Per cent. silicon.
1.	50	5 minutes	0·657
2.	50	4 "	0·639
3.	50	4 "	0·629
4.	25	2½ "	0·639

No. 3252. Regular method. Silicon, 3·858 per cent. Rapid evaporation.

	C. c. acid.	Time for evaporation.	Per cent. silicon.
1.	50	5 minutes	3·863
2.	50	5 "	3·849
3.	50	3 "	3·765

No. 2074. Regular method. Per cent. silicon.

1.	"	2·374
2.	"	2·384

Rapid evaporation.

	C. c. acid.	Time for evaporation.	Per cent. silicon.
1.	50	5 minutes	2·374
2.	50	5 "	2·328
3.	50	5 "	2·276
4.	50	4 "	2·320

No. 1967. Regular method. Silicon, 1·829 per cent. Rapid evaporation.

	C. c. acid.	Time for evaporation.	Per cent. silicon.
1.	50	5 minutes	1·955
2.	50	4 "	2·058
3.	50	4 "	2·010
4.	50	5 "	1·810
5.	25	3 "	1·904
6.	50	3 "	1·913
7.	50	3 "	1·815

No. 4 of this series lost silica in igniting. No. 7 was completed in twenty minutes from the time of opening

the balance case. Ten minutes was consumed in filtering, and the carbon burned off in the old way. By igniting with oxygen, and filtering more rapidly, the time for a complete determination can be undoubtedly reduced to fifteen minutes.—*Journal of Analytical Chemistry*, vol. iii., part 2, April, 1889.—*Chem. News.*

[Continued from Supplement, No. 710, page 11347.]

OPTICAL TORQUE.*

By Prof. Silvanus P. Thompson.

II.

It will be convenient here for me to refer to some researches, not yet published, which I have made, as to the various orders of transition tints, with the view of ascertaining which of them is the most sensitive—which of them, in fact, shows the greatest change of tint for the smallest amount of rotation. Reference to the diagram on the wall displaying Newton's tints will make clear what I mean by the transition tints of the several orders.

The tints obtained from quartzes of varying thicknesses may be considered as approximately identical with the tints of Newton's rings, provided we remember that the air film which gives any particular tint in Newton's rings is about 1/300,000 part as thick as the quartz which yields the corresponding tint in the polariscope. Better far than any painted diagram, because richer and purer, are the tints now thrown upon the screen by introducing into the field a thin wedge of selenite, displaying the whole of the colors of the first three orders of Newton's scale. You will notice the successive recurrence of purple tints, both in the colors seen in the bright field and in those seen in the dark field.

First I will show you the transition tints of the first and second orders in the bright field. That of the second order is much less intense than that of the first, and yet is very sensitive, turning to a green tint while the first order purple has only turned to a blue. On the other hand, with reversed rotation of the analyzer it turns to red less rapidly than does the tint of the first order.

Next I take the transition tints of orders I., II., and III. in the dark field. These, though arranged, by means of superposed half disks of "quarter-wave" plates, to be optically equivalent to biquartzes of two rotations, are really built up of selenite and mica. You will notice how the tint of order I. surpasses in sensitiveness both the others. I cannot here show you on the screen the means by which I have compared the tint of order I. in the dark field with that of order I. in the other set. Suffice it to say that I find the tint of order I. in the dark field—corresponding to 7·5 millimeters thickness—more sensitive than that of order I. in the bright field, which corresponds to 3·75 millimeters thickness.

A method which was at one time supposed to be more precise, was that of placing a spectroscope (or its prism) in front of the analyzer, and watching the motion along the spectrum of the interference bands which are then seen. My three pieces of crystal remain. I introduce a slit in front of them, also a single film of quarter-wave mica, and then a prism to give the spectrum. This prism (Fig. 9), by the way, is a new

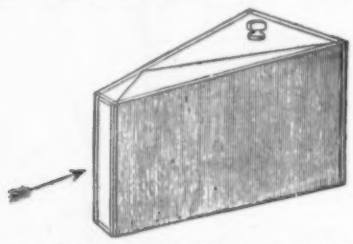


Fig. 9.—DIRECT-VISION PRISM FOR PROJECTION OF SPECTRUM.

sort of direct-vision prism, having a single very wide-angled prism of Jena glass inclosed in a cell with parallel ends containing cinnamic ether (first recommended by Wernicke), a liquid which has the same mean refractive power, but widely different dispersion. It is preferable to bisulphide of carbon in several respects: first, its odor is a delicate reminiscence of cinnamon; it is barely volatile; and it is whiter than bisulphide. This prism, which is shown also in plan in Fig. 10, was

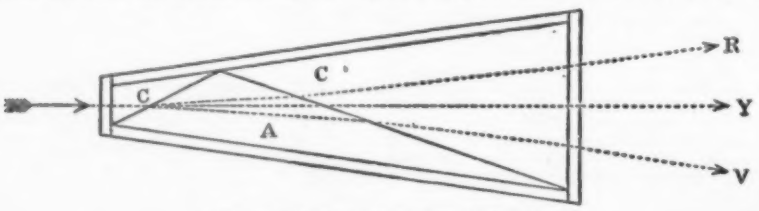


Fig. 10.—DIRECT-VISION PRISM

A, wide-angled prism of Jena glass; C, cinnamic ether.

constructed for me by Messrs. R. & J. Beck. It will be seen that the dark bands in the spectrum are nebulous and ill defined. It is idle to hope to secure accuracy by turning the analyzer until they shift along to a definite point. And there is no advantage in using the higher orders of tints which give more bands; for, though the bands are certainly better defined, their progression across the spectrum for a given amount of rotation is proportionally smaller.

Another suggestion, due to Senarmont, is to use two sets of superposed wedges of right and left handed quartz. Such you now see before you. Instead of starting with extinction, you start with coincidence between the upper and lower set of bands. Any rotation of the light shifts the bands, one set moving to left, the other to right. By turning the analyzer through an equal angle, coincidence is again obtained.

Another method, used by Wild in his polariztrobometer, is to produce the phenomenon known as Savart's bands (due to the introduction of two crossed slices of quartz cut at a particular angle). The bands disappear when the analyzer is set in a particular direction. Anything that twists the plane of polarization causes them to reappear; but they again fade out when the analyzer is turned through an equal angle.

There is yet another method in polarimetry, due to Soleil, in which the optical torsion due to the sugar is counterbalanced or compensated by introducing a pair of sliding wedges of quartz of the opposite rotation. This device is known as a "compensator." By sliding the quartzes over one another a greater or less thickness of quartz is introduced at will. But I must not stop to illustrate this elegant device.

Yet one other method must be mentioned, and this is certainly the most preferable. It consists in aiding the eye to recognize with precision a particular degree of extinction, by the device, first suggested in 1856 by Pohl, of covering a portion of the visible field with something which slightly alters the initial plane of polarization, so that complete blackness is not obtained at once over both parts of the field. A common device is to cover half the field with a slice of some thin crystal—mica or quartz—so that only one half can be perfectly black at any instant. As an example, here is the field covered half over with a plate of mica of the thickness known as half wave. The result is that when one half of the field is black, the other is light. Adjust the analyzer now to equality. Now introduce something that rotates the light—say a tube with sugar solution in it. At once the balance is upset, and I must, in order to get equality, turn my analyzer.

Of the same class are the polarimeters with special prisms made in two parts slightly inclined to one another. The earliest of these was devised by the late Prof. Jellett, of Dublin, and has been followed by imitations of the same plan by Cornu, by Lippich, and by Schmidt and Haensch. The beautiful "shadow polarimeter," by the latter firm, which I here exhibit, has the divided prism and a quartz compensator.

I have suggested two simpler methods of accomplishing the same end. In the first place, I have proposed to use *twin prisms*. These are made on a plan suggested to me by finding that Mr. Ahrens' method of cutting calc-spar for prisms was admirably adapted for making such prisms, either with wide or narrow angles between the respective planes of polarization in the two parts of the visible field. Two such twin prisms, one with 90°, the other with 2½°, between the prisms, are here on the table. In the second place, I have essayed a polarimeter, an example of which is before you, in which an arrangement of twin mirrors (each set at the polarizing angle, but slightly inclined to one another) is made to yield a half shadow effect.

Before I leave the subject of quartz I must refer to the famous mathematical theory of Fresnel, who endeavored to explain its action upon light by supposing that the plane-polarized wave on entering it is split into two waves, consisting of oppositely circularly polarized light, which traverse the crystal with different speeds. On emerging they recombine to form plane-polarized light, the plane of which, however, depends on the retardation of phase between the two components. I here introduce a mechanical model to illustrate one of the points in this theory—namely, the recombination of two circular motions to form a straight-line motion. These two disks (Fig. 11), which turn in opposite

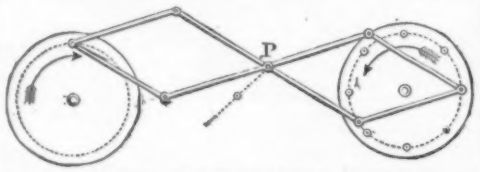


Fig. 11.—MODEL ILLUSTRATING RECOMPOSITION OF RECTILINEAR MOTION FROM TWO OPPOSITE CIRCULAR MOTIONS.

senses, but at equal rates, represent two circularly polarized beams of light. The linkages, which connect two pins on these disks, compound their motions at the central point, P, which executes, as you see, a straight line. But now, suppose one of these circular motions to be retarded behind the other, an effect which I can imitate by shifting one of the pins to another position on the disk. Still the resultant motion is a straight line, but it is now executed in a direction oblique to the former. In other words, its plane has been rotated. Of course this model must not be taken as establishing the truth of Fresnel's ingenious theory: it is at best a rough kinematical representation of it.

We have, however, the puzzling fact still to account for that there should be two kinds of quartz crystals, right and left handed. Sir John Herschel first showed that natural crystals of quartz themselves often indicated their optical nature by the presence of certain little secondary faces or facets which lay obliquely across the corners of the primary faces. These are indicated in the diagrams (Fig. 12 and 13), and may be seen in two specimens of quartz crystals which lie upon the table. The largest of these is right-handed. The wider generalizations of Pasteur, respecting the crystalline form of optically active substances, show that those substances which exercise an optical torque, whether as crystals or in solution, belong to the class of forms which the crystallographer distinguishes as possessing non-superposable hemihedry. In other words, they all show *skew symmetry*, as if in the growth of them they had been built up in some screw fashion

R

Fig. 12.—QUARTZ CRYSTAL, SHOWING CHARACTERISTIC FACETS—RIGHT-HANDED.

L

Fig. 13.—QUARTZ CRYSTAL, SHOWING CHARACTERISTIC FACETS—LEFT-HANDED.

around an axis, and must therefore be either right-handed or left-handed screws. By piling up a number of wooden slabs in skew-symmetric fashion, I am able roughly to illustrate (Figs. 14 and 15) the difference be-

Fig. 14.—SKEW-SYMMETRICAL ARRANGEMENT —RIGHT-HANDED.

Fig. 15.—SKEW-SYMMETRICAL ARRANGEMENT —LEFT-HANDED.

tween the right-handed and the left-handed structure. It is a curious fact, if I am rightly informed, that down to the present date the only substances possessing this skew symmetry are natural substances; that those which the chemist can produce by artificial synthesis are all optically inactive. It is perhaps equally significant that as yet no inorganic substances have been found which will in the liquid state rotate the light. This appears to be a property possessed solely by certain compounds of carbon. Quartz fused in the blowpipe or dissolved in potash shows no trace of rotatory power.

Yet we can have little doubt that this property is bound up in the yet unraveled facts of atomic and molecular structure. In the case of the liquids, such as turpentine and sugar solution, there must be some skew symmetry in the grouping of atoms in the molecule to produce the result. In the case of quartz, there must be a skew in the building of the molecules—there must, to borrow a phrase from the architect, be an oblique *bonding* of the minute bricks of which its transparent mass is builded. Though we cannot even rebuild it from its solution, we know this must be so, for we can reproduce all the optical phenomena which it exhibits by an actual skew building of thin slices of another non-rotatory crystal. Here is an artificial object (I built it myself) constructed on Reusch's plan, from sixteen thin slips of mica built up in staircase fashion—right-handedly—one above the other, and set symmetrically at equal angles of 45° to one another, the whole set making a corkscrew of two complete turns. In the lantern it behaves just as a quartz of about nine millimeters thickness would do. It even gives tolerably perfect rings, as quartz does, when viewed by convergent light.

I must now pass hastily onward to the great discovery of Faraday. Here (Fig. 16) is a magnetizing coil of wire, M, having about 8,300 turns, and inclosed in an iron jacket. When it is traversed by a powerful electric current from the dynamo machine, it produces

* A discourse delivered at the Royal Institution, May 17, 1889, by Prof. Silvanus P. Thompson.—*Nature.*

an intense magnetic field along its axis. In this axial position lies a bar of heavy glass, not quite so dense as that which Faraday himself used, but nearly so. The bar lies along the line of light from our lantern, but the polarizer, P (the Ahrens reflector, Fig. 7), and analyzer, A (the Ahrens triple spar prism, Fig. 6), are crossed, so that here is the dark field. On turning on the current, light is at once restored, being twisted to the right when the current circulates right-handedly. To measure the rotation, I must turn the analyzer; and now I find that, owing to the greater rotation of blue waves than of red, complete extinction does not occur. Introducing a half shadow plate, and using colored glasses, it is very easy to verify the greater amount of rotation for blue light, and to show that reversing the current reverses the rotation. You will perhaps better understand it if I use (as in Fig. 16)

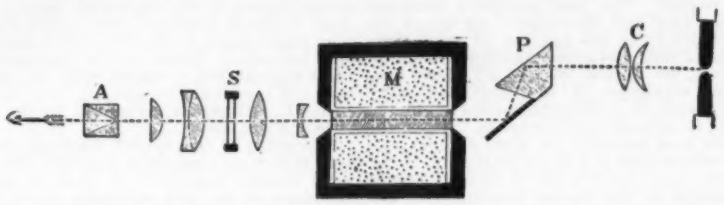


FIG. 16.—PROJECTION OF MAGNETIC ROTATION OF PLANE OF POLARIZATION.

C, condensing lenses; P, reflecting polarizer; M, magnetizing coil surrounding bar of heavy glass; S, mica disk of twenty-four rays; A, analyzer (Ahrens' triple prism).

the 24-ray star, S, which I have previously employed. It is now obvious to you that there is a large rotation—over 50° in fact—which is reversed when I reverse the magnetizing current. We have thus repeated the fundamental experiment of magneto-optics. But now we meet with another consideration. Reflect that the circulation of current, if it be taken as right-handed when regarded from one end of the coil, will be left-handed when regarded from the other end of the coil. This is, therefore, no case of skew symmetry: it clearly indicates that something is going on in the glass which tends to twist the light quite irrespective of which way the light enters.

The next magneto-optic phenomenon is that discovered by Dr. Kerr, of the rotation of the plane of polarization by reflection at the surface of a magnet. To observe this at all requires good apparatus and a keen eye. So far as I am aware, it has never been projected on the screen. If I can succeed in doing so, it will only be because I have special means of the most favorable character for so doing. We withdraw the bar of heavy glass from the coil, and replace it (Fig. 17) by an iron core pol-

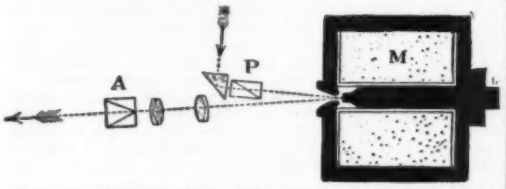


FIG. 17.—APPARATUS FOR PROJECTING ROTATION OF PLANE OF POLARIZATION BY REFLECTION AT POLE OF MAGNET.

P, polarizer; M, magnetizing coil with coned iron core; A, analyzer.

ished at its coned end. This will be intensely magnetized when the current is turned on.

Now we must throw the beam of light obliquely down the hollow of the coil, polarizing it by one of my improved Nicol prisms, P, as it goes down. After reflection it is focused by a lens which sends it through the analyzing prism, A. You see the dim spot of reflected light upon the screen. Now for the current: "on," "off," "on," "off." Reversing its direction ought to double the amount of torsion.

While Mr. Thomas is making the needful arrangements for the next experiment, I may mention that it was found by Kerr that the effect was approximately proportional to the magnetic induction through the iron. I have myself tried some further experiments: for example, using a bar of lodestone instead of an iron core. The light reflected from lodestone is also twisted. I should expect the ferro-aluminum alloy which Sir H. Roscoe showed us a fortnight ago to do the same thing, because that alloy is, as I have found, susceptible of magnetization. But I should not expect manganese steel to rotate the light, because of its singularly non-magnetizable nature.

The experiment of Kundt, transmitting polarized light through a thin transparent film of iron, magnetized normally while the light is passing through it, is another difficult of repetition before an audience. The small disks are here covered with films of iron, kindly prepared for me by Mr. Crookes, by squirting them electrically in a high vacuum. But the thin ones barely transmit enough light to make the observation of the effect possible even to the solitary observer. I have observed the effect projected on the screen, using this very coil and these transparent mirrors. It requires, however, an absolutely dark room, and is at best so faint that it would be hopeless to attempt to show it to a large audience.

Prof. Kundt has not only observed similar rotations in other magnetic films of nickel and cobalt, but has even shown that the degree of rotation of the light is proportional not to the magnetizing force, but to the resulting magnetic induction. This is a result of utmost importance in considering the theory of the phenomenon. He has further shown that, whereas the magnetic rotations in elementary bodies, whether magnetic or diamagnetic, are in the same sense as that in which the current circulates, the magnetic rotations in compound magnetic bodies, such as a solution of sulphate of iron in water, are in the opposite sense.

These experiments with transparent mirrors of iron raise interesting speculations as to the probable nature of a transparent magnet, if such there could be. It is one of the cardinal points of Maxwell's celebrated electro-magnetic theory of light, that the better a body conducts electric currents, the greater is its tendency to absorb light and become opaque. Now, suppose it were possible to obtain a substance such as to possess greater electric conductivity in one direction than in another, such a substance ought to absorb those vibrations of light which are executed in the direction of the greater electric conductivity more than those in the direction at right angles. In other words, such a substance ought, like the tourmaline, to polarize light by absorption.

Now, since the researches of Sir W. Thomson in 1856, we have known that the electric conductivity of iron is altered in the direction of the magnetic lines of force, when it is powerfully magnetized. More recently it has been discovered—I myself observed it in tinfoil, and announced the discovery to the Physical Society a few days before the announcement of the same fact by Righi—that non-magnetic metals alter their resistance in the magnetic field. Notably so do bismuth and tellurium. I had therefore conceived it possible that a film of iron or possibly of tellurium, if strongly magnetized in its own plane, might exhibit polar absorption and act like a tourmaline. Unfortunately if the effect exists it is so faint as to be yet undiscovered, though I have made many efforts to find such. I have further tried to obtain a similar result by making a transparent magnet out of a film of magnetic oxide of iron, precipitated chemically. In this, too, I have not succeeded. I have tried to precipitate a transparent film of magnetic oxide in the midst of a transparent jelly. And I have mixed particles of precipitated oxide with melted gelatine so as to get a film.

In this way I hoped to get, by placing the preparation in a strong magnetic field, a sort of magnetic structure which would operate upon waves of light. That such a task was not hopeless was shown by two facts: first, that many mere vegetable and animal structures can act as polarizers; and second, that a mere film of paint, such as indigo, can, if a proper mechanical drug is given to it so as to produce structure, also act as a polarizer.

The film of indigo carmine which I have here acts nearly as strongly, though not quite as evenly, as a tourmaline slice, and costs but a fraction of a penny.

Well, my films of jelly inclosing particles of magnetic oxide of iron do faintly act on polarized light; but their action is not as marked as that of films of jelly inclosing actual small scraps of iron. This film, when placed across the poles of this electro-magnet, between two Nicol prisms at 45°, shows an action when the magnet is turned on, as you see by the way in which it flashes into light in the dark field. When the jelly is fresh and of the proper consistency, the action is very strong, but with the rather dry sample before you I fear we can only call the effect a *succes d'estime*.

Incidentally, in the course of these experiments on magnetic films, I came across a new magnetic body unknown hitherto, I believe, to the chemist—namely, a magnetic double oxide of cobalt and iron—a ferroso-cobaltic oxide, I think—a black powder, a sample of which I have here.

It also occurred to me, as a matter of speculation, that if I could strongly magnetize a crystal of ferrous sulphate or nickelous sulphate, while viewing it by convergent polarized light, I might find some interesting phenomena, which should, if they existed, show some sort of a relation between the direction of the optic axis and that of the lines of the magnetic field. I thought that a longitudinal magnetization might possibly set up a rotatory phenomenon like that in quartz in so far as to disturb the central field between the arms of the black cross; however, not by the most powerful magnetizing could I discover any such effect. Again, I thought that by magnetizing transversely to the optic axis I might possibly succeed in turning the uniaxial crystal into a biaxial, or producing by magnetism an effect resembling the action of heat on crystals of selenite. Owing probably to the small depth of any crystals that can be obtained, I have failed so far to obtain any such effect, though I am convinced that it must exist.

An effect precisely analogous to the magnetic effect which I vainly sought has, however, been lately discovered by Prof. Rontgen. I sought a distortion of the optic axis by transversely magnetizing, and I sought it in crystals of sulphate of nickel; he has found a distortion of the optic axis by transversely electrifying, and he has found it in crystals of quartz.

Suppose a piece of a quartz crystal is cut as a square prism, its long faces being principal planes of section respectively parallel to and at right angles to two of the natural faces of the hexagonal prism. Fig. 18 shows

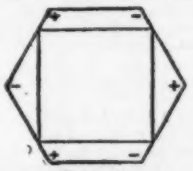


FIG. 18.

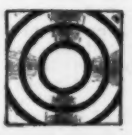


FIG. 19.

the form of the portion cut. The + and − signs in this figure refer to the pyro-electric poles of the crystal. Such a piece viewed by convergent light shows the usual rings and black cross with a colored center (Fig. 19). If now two opposite faces be covered with tinfoil, and the crystal be electrified transversely, the rings are distorted into lemniscates, the direction of the distortion changing with the sign of the electrification. It is necessary to use a red glass, or still better sodium light, to observe the changes in form on reversing the sign of the charges. Figs. 20 and 21, 22 and 23, show the changes of form, but these sketches grossly exaggerate the effects. As you see upon the screen, when the charges imparted by this fine Wimshurst machine are rapidly reversed, there is a decided distortion of the rings, but it is small in amount.

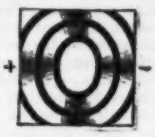


FIG. 20.

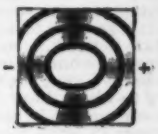


FIG. 21.

FIG. 22.

FIG. 23.

Returning to the phenomena of the rotation impressed by magnetism on polarized light, I may point out that the torque which a magnetic field exerts on the light waves appears to be really an action upon the matter through which the light waves are passing. It is as though the magnetic field were really a portion of space rotating rapidly on itself, or perhaps as though the ether were there rotating, and that this rotation in some way dragged the particles of matter along with it. It has long been supposed necessary, in order to account for the refractive and dispersive properties of transparent bodies, to consider that their particles are in some way concerned in and partake of the vibrations going on in the ether within them or between their molecules. It is impossible to explain the phenomena of magneto-optic rotation by the supposition that any skew structure is imparted to the medium; for these phenomena, unlike those of quartz, do not exhibit skew symmetry. There seems to be no other way of explaining the magneto-optic torsion of light than by supposing that the molecules of matter in the magnetic field are actually subjected to rotatory actions; as indeed was suggested long ago by Sir William Thomson.

However, there is room here not only for speculation, but for experiment. Some day, when facts enough have been collected, we shall be ready to build thereon the wider generalization which at present seems to escape us.

So far we have been applying an optical torque to previously polarized light, and producing a torsion of it. It remains for me yet to describe the means by which, in the hands of Prof. Abbe and Prof. Sohncke, it has been demonstrated that natural, non-polarized light is actually rotated when subjected to an optical torque.

The way of doing this is to make use of the principle of interference. Here is a slit from which a narrow beam of light waves issues. At a point a little distance away is a Fresnel's biprism which splits up the light (without polarizing it) into two beams, just as if we had two slits or sources of light. These two beams pass along and meet upon this distant screen and give us—what? A set of interference fringes, having a bright line down the middle, because this part of the screen is exactly equidistant from the two sources of light.

But these dark interference fringes that lie right and left can only exist because, in the first place, the vibrations have traveled unequal paths differing by an odd number of half wave lengths; and secondly, because (owing to the method adopted of using two images of one slit) the phases of the emitted waves from the two sources are identical.

This being so, let us now introduce across the two interfering beams of light a special biquartz, made of right and left handed quartz of only 1·88 mm. thick. This will rotate—*if it rotates natural light at all*—the yellow light in one beam 45° to the right, and that of the other beam 45° to left. The angles will be a little more for green and blue, a little less for red and orange. Consequently we shall not get quite a perfect result for all kinds of colors. But for the main body of the light the result is this: that because the two beams have had their respective vibrations turned so that, whatever their primitive positions, they are now at right angles to one another, they cannot interfere. In other words, if it be true that the quartz rotates natural light, the interference bands will die out. [Experiment shown.]

Here I have the light passing through the biprism only, and giving us this narrow series of interference bands. You must notice carefully—with opera glasses if you have them—the narrow bright and dark stripes.

Now I shift this little diaphragm so that the light passes through the biquartz as well. Instead of sharp interference bands, we have merely a dull line of nebulous light. The disappearance of the fringes proves that quartz does twist the not previously polarized waves of light.

That the magnetic field can also exert a magnetic torque on non-polarized light is readily proved, at least when one already has the biquartz. Two strips of heavy glass of exactly equal length and similar quality, such as those I hold in my hand, must be introduced in the respective paths of the two beams; and one at least of them must be surrounded by a magnetizing coil. The biquartz has wiped out the interference fringes; but on magnetizing one of the two pieces of heavy glass, or on magnetizing the two in opposite senses, the interference bands can be made to reappear. It is in this way that Prof. Sohncke's experiment—hardly suitable for a lecture theater—was performed. It is in this way that we establish upon an experimental basis the fact that light itself, and not merely the plane of its polarization, experiences an optical torsion when subjected to those forces which, whether crystalline, molecular, or magnetic, exert upon it an optical torque.

THE SOLAR SURFACE DURING THE LAST TEN YEARS.*

By the Rev. S. J. PERRY, D.Sc., F.R.A.S., Director of Stonyhurst College Observatory.

THE solar surface is a subject on which so much has been written of late years, that it would be highly unsatisfactory to attempt in one short hour even a brief enumeration of the results obtained and the theories advanced by the many eminent men who have devoted attention to this branch of solar physics. The end which I propose to myself this evening, and which, I venture to think, is most in accordance with precedent in these discourses, is to lay before you, in as clear a manner as I am able, the results obtained at the observatory to which I am attached, in so far as they enter into our present subject, and to touch upon the work of others in such a manner only as to complete the picture, by showing the bearing of our labors on the general result.

For the last ten years I have been anxiously endeavoring to make Stonyhurst as efficient an observatory for solar physics as the means at my disposal would admit, so I was naturally desirous not to undertake any work that would be a mere repetition of what was being done better elsewhere. From the outset, therefore, I excluded from my programme a daily photograph of the sun, as this had been already undertaken at the Royal Observatory, assisted by other government observatories in India and at Mauritius, and the most I could have hoped for in this direction would have been to fill up a few gaps in an almost perfect series. My choice, therefore, lay between drawings made at the telescope by aid of a solar eyepiece, and the use of a sketchboard on which the sun's image could be projected. The object in view being to procure the most complete and faithful representation of nature, I had no hesitation in rejecting all forms of solar eyepieces, as by this method of observation too much is left to the imagination of the draughtsman; although a solar prism is not unfrequently of great advantage in supplementing other methods of attack, especially when delicate details require verification. The sketchboard, on the other hand, may be so used as to leave very little indeed to the ideas or bias of the observer. To effect this the following method has been adopted.

A circle 10¼ in. in diameter is first traced upon a piece of drawing paper, which is pinned to a board just rigid enough to hold the paper firmly, and then the whole is clamped on to the eye end of the telescope. The eyepiece and board are each capable of fine adjustment, so that the sharpest image of the sun may be made just to fill the 10¼ inch circle, and a marked diameter of the picture is brought into precise coincidence with the direction of the daily motion. The clockwork of the equatorial then keeps the image fixed in position on the paper, while an accurate outline is traced of the umbra and penumbra of every spot visible on the disk. When the sky is clear this outline can be made as correct as the finest point of a hard pencil can delineate it; and even when, as so often happens, the transparency of the atmosphere is changing every moment, a short time at the instrument will generally enable the observer to verify the perfect accuracy of his sketch.

The details are then filled in as quickly as the nature of the sky permits, each portion of the drawing being over and over again brought into coincidence with the projected image, in order to detect and remove the slightest difference between them. By this means the final picture gives the advantage of all the best moments of seeing that occur during the progress of the observation, and not merely the result at one single moment, which may be far from the best for definition even on the finest day. Immediately the spots have been completed the faculæ are traced, and their details reproduced as nearly as possible: By the advice of Professor Stokes, P.R.S., a red pencil is used in drawing the faculæ, and thus the difference between bright and dark markings and their connection with each other stand out much more boldly than if the same black pencil were used throughout. Finally, when the sky is good for definition, the general surface of the sun is carefully scrutinized for some time, and any peculiarities noted.

The sun's image having thus been sketched and examined, the drawing board is replaced by an automatic spectroscope of six prisms of 60 degrees, through each of which the light may be made to pass twice, and to which may be added a Hilger-Christie half prism, raising the total available dispersion to about thirty-six prisms of 60 degrees. The chromosphere is measured with the slit radial, a dispersion of six prisms being generally used; and when the definition is very good, a sweep is made round the limb, with twelve prisms and a tangential slit, to study the forms of the prominences and the direction of the currents in the chromosphere. Spot spectra have been occasionally observed with the same instrument; but lately (in a room adjoining the equatorial dome) a large grating has been mounted, with which it is proposed to take daily photographs and eye measurements of the spectra of sun spots. A heliostat and a 5½ inch object glass of Alvan Clark are used in connection with the grating spectroscope. The combination of this solar observatory with an establishment supplied with a complete set of self-recording meteorological and magnetic instruments affords a ready opportunity of comparing solar results with the daily photographic records of terrestrial phenomena.

As it is most important, before referring to any conclusions that may be drawn from our observations, to test severely the fidelity of which solar drawings are capable, I will throw upon the screen a number of sun pictures drawn at Stonyhurst, and enable you to contrast them with sketches of the same spots made by experienced astronomers in England, and at Brussels, Palermo, and Kalocsa, and also with photographs taken at Dehra Dun and at Meudon; and I think these few examples will amply suffice to vindicate a high character for solar drawings. But I have not been satisfied with this ready comparison, and lately this solar work has been put to a more rigid test of accuracy by placing side by side the measurements of areas obtained from drawings and photographs; and here again the hand sketch by projections seems to bear well the scrutiny. The method of projection not only permits the area covered by spots and faculæ to be accurately determined, but it also furnishes precise data for finding the heliographic co-ordinates of any mark upon the solar surface. These, however, are now given so fully in the annual publications of the Royal Observatory, and each individual spot can be so readily identified, that an independent calculation would be a mere waste of time and energy. The results, therefore, dependent on position alone are deduced immediately from the Greenwich tables.

The decade of years which we are now considering covers almost an entire solar cycle, that period of eleven years the proof of whose existence was the fruit of the unwearied labors of Baron Schwabe, in his daily observations from 1826 to 1868. The present cycle falls much below that which preceded it in the extent of its spotted area, but it is remarkable for the duration of its maximum period. The last minimum occurred about November, 1878, and therefore if we accept the mean values 3·7 and 7·4 as the number of years from minimum to maximum and from maximum to minimum respectively, we obtain 1878·9 + 3·7 = 1882·6 as the date of the maximum of the cycle, and 1882·6 + 7·4 = 1890 as the epoch of the approaching minimum. Many facts seem to support this conclusion. Thus, the greatest sun spot area occurred on April 21, 1882, and the largest individual spot was at its maximum on November 18 of the same year, when it covered almost one four-hundredth of the visible hemisphere. The total spot area in April reached, however, the much higher figure of one one-hundred-and-eightieth, or about 6,000,000,000 square miles, which on the following day had diminished to something under 4,000,000,000, showing the marvelous activity of the solar forces at the epoch. In the same year also the mean monthly amount of umbra was greater in April and in November than at any other time of the cycle, making it highly probable that the disturbances then penetrated more deeply below the surface of the photosphere. Again, if we consider the mean latitude of the spotted area, its value at the maximum seems also to favor the claims of 1882; and these are still more strengthened by the number of times in which the spectral lines have been found contorted in the observations of the chromosphere. But, on the other hand, it may be urged, that if we reckon the days without spots, we find very little change from 1880 to beginning of 1885; and the monthly mean area of sun spots was slightly in excess in July, 1883, of what it had been in the previous year; and even as late as June, 1885, we meet with days on which the spotted area was larger than the mean extent for any month in 1882 or 1883. May it not be possible that the great comet of 1882, which passed so deep within the limits of the corona, and which seems to be but one of a numerous family, may have exercised some disturbing influence, and been a partial cause of this prolonged maximum?

The limits are rather wide for the periods separating maximum from maximum, but there is much more steadiness in the lapse of time between successive minima, and if we may judge from the present rapid increase in the number of days without spots, the next minimum should be fast approaching, and may not be far removed from the computed epoch of January, 1890.

Thus, against one spotless day in 1884, we have 10 for 1885, 61 for 1886, 106 for 1887, 160 for 1888, and more than half the days that have been fit for observation since the beginning of the present year. The important law connecting the mean latitude of sun spots with their extent of area, first published by Carrington, and afterward so vividly represented in curves by Professor Sporer, has received a fresh verification in the present cycle. In close relation to this is the distribution of spots in the two hemispheres, and this can be well illustrated by aid of curves and by mapping each spot in its true heliographic position. Thus we find that the greater activity of the southern hemisphere since 1883 is strongly marked, and there seems to be very little evidence that successive spots tend to form along meridians, although examples of this are not wholly wanting. A general glance at spot distribution shows that an outbreak may be expected on any meridian, but that at certain times spots congregate more thickly in one longitude than in another. Thus, in 1881 and 1882 the longitudes most favored lie between 180 degrees and 270 degrees, while in 1887 more spots appeared between 0 degrees and 90 degrees. The preponderance of southern spots in this year is very striking.

The variability of the sun spot area which we have been so far considering is a point of the greatest interest in solar physics, and it may even become of great practical importance, if the supposed connection between certain terrestrial phenomena and solar cycles is once clearly established. But apart from this, the study of spots in themselves, their wonderful changes, and their individual history, may be highly instructive, and teach us much concerning the nature of the solar surface. The spots seen first in March and April, 1884, and which reappeared in May and June and July, furnish excellent examples of the formation of companion groups, the principal spot acquiring a regularity of outline, when it stands alone in middle life, and regaining new companions as it hurries on to its final extinction. The last few years have also afforded some striking instances of the repulsion and proper motion of spots, so clearly brought out in the researches of Carrington. Perhaps the most remarkable change of this nature recorded at Stonyhurst occurred between May 27 and 28, in 1884, when a spot of considerable size, situated between two others, moved through a great part of the distance separating its two companions. Another class of observations consists in noting the variety of tints connected with the bridges and other bright portions of intricate spots, and which are seen only from time to time.

Thus, in 1884, on May 5 and July 6, there were outbursts of a crimson hue in the center of spots. Such appearances vary in duration as much as in color. On one occasion a reddish brown tint, very noticeable on the bright separations of the umbra of a spot, did not remain constantly visible, but was intermittent. At another date a yellowish green tint remained visible for several days on the bridge crossing a spot. In each case the colored portion was carefully compared with other parts of the disk, so as to ascertain whether the effect might not be due to the object glass or eyepiece.

Some useful hints in view of future theory can certainly be gained by a careful study of the peculiar forms assumed occasionally by the penumbra of spots, not when the whole area is in a state of violent commotion, for then it is conceivable that any form may possibly present itself, but when the umbra is regular and the spot quiet. I would especially draw attention to some examples of multiple penumbræ observed in 1882 and 1883, which seem to indicate that such disturbances are due to successive impulses from a common center. Or, again, I would point to the penumbral matter extending from the nucleus of certain spots in 1884, which might reasonably be adduced as evidence of an apparent outflow of a floating substance.

It is doubtless fascinating to argue in support of some exhaustive theory, complete in itself, and able alone to offer a satisfactory explanation of every observed appearance; but may it not be possible that several true causes concur in the production of solar phenomena? And, if this be admitted, then a line too hard and fast may easily stand in the way of the true explanation of spot formation. Might not the last mentioned observations suggest the question whether absorbent vapors may not sometimes be cast up from the seething mass beneath, although a downrush be the prevailing feature of a sun spot?

The study of the bright markings on the solar surface is perhaps somewhat less interesting, although almost equally important as that of the spot area, but the state of the sky interferes much more seriously with the former class of observation than with the latter. The clustering of faculæ about nascent spots, their spreading as the spots get older, their lingering long after the parent spots have disappeared, the apparition of fresh spots in their midst, are facts of constant recurrence. That faculæ are the first evidence of a coming disturbance has never been observed at Stonyhurst, but a region where faculæ abound has always been found to have previously been occupied by a group of spots.

Such an observation as that of the birth of the great November spot of 1882, and other similar instances are not wanting, in which a few dots, in a region of perfect calm, suddenly developed into a vast center of disturbance, is a strong proof that the law which regards faculæ as the constant forerunners of spots cannot be accepted as universal. Do not such instances as these give some additional weight to the opinion that large spots owe their origin rather to an external cause, as the prime mover, than to the internal forces of heat and pressure and chemical affinity? Might not the latter forces, however great, hold each other almost in equilibrium until their energies are freed by the advent of an external, though perhaps lesser, disturbing force? The periodicity of sun spots, their total absence for months, nay almost for years, combined with their enormous development and rapid changes about the epoch of maximum area, seems to preclude the possibility of internal forces, in a gaseous body, being the sole cause of such phenomena; although there appears to be no reason why these forces should not exercise an overwhelming influence when called into play by an external agent.

The distribution of faculæ, especially of small isolated patches, is much more general than that of spots, many being visible even near the sun's poles, and this has been forced upon my attention more and more of late as we have approached nearer the minimum of the cycle.

Another point, which is often accepted as established, is the lagging of faculæ, and it is sometimes adduced as a proof that faculæ are cast up from a lower level, for thus in possessing a less linear velocity than the surrounding photosphere, they would naturally be left behind. The observations of the present cycle can scarcely be said to add to the stringency of this argument, as out of more than 4,000 cases recorded in the Greenwich tables 74 per cent. lean neither way, and of the remainder 5·7 per cent. show the faculæ preceding, against 20·3 per cent., which alone are in direct confirmation of the assumed law.

The general surface, with its ever-varying aspect, can never be adequately represented by the pencil, but in this case recourse must be had to the instantaneous photograph. And yet it is true to say that even in this branch of the subject much may be done by the method of projection, and light may thus be thrown on many points which could scarcely be settled by photography alone. I refer particularly to any possible variation of tint in definite regions of the solar disk, to rapid and continuous changes, and to such appearances as the smugged areas in the photographs, which suggest at first bad definition, but which are in reality evidence of a new form of disturbance not indicated by other phenomena. Watching the image of the sun as it depicts itself upon the drawing board, we soon perceive that no part of the surface is long at rest. Everywhere are seen small dark shadowy objects, attracting special attention now in one place and then in another, sometimes forming groups, and at other times almost companionless, affecting no special zone, and combining with no other form of solar marking, except occasionally with a few bright faculæ.

These dim, ill-defined objects seem first to have been observed in 1875 by Trouvelot, who gave them the name of veiled spots. They soon forced themselves into notice when our daily sun work was started at Stonyhurst, and ever since they have never failed to be carefully watched. At first they were divided, for convenience, into three classes, but on further examination there seems to be no need of more than a single distinction. When they first catch the eye, all present much the same general appearance, resembling small fragments of ill-defined penumbra, but their position on the disk, and still more their duration, soon enable the observer to distinguish the class to which they belong. Those of the first class appear in all heliographic latitudes, and never remain visible for more than two or three minutes; while the others, which have been called sub-permanent spots, are confined exclusively to the spot zones on either side of the equator, and this class may remain on the disk for two or more days. Sub-permanent spots are not always to be found on the surface of the sun, their tint is a shade less dull than that of the other veiled spots, and occasionally there is almost the appearance of an umbra in their midst, though this rarely could be mistaken for a true umbra. For, even when their shading is in some parts more intense than in others, the whole remains always ill-defined, and the limits of its several parts are hard to

* Lecture delivered before the Royal Institution of Great Britain, May 24, 1889.

distinguish. Frequently these dim objects show themselves in considerable numbers in the neighborhood of fully developed spots, but then the latter are generally approaching their time of dissolution. They may, perhaps, aptly be described as imperfectly developed or dennumbral spots, and consequently be included in the ordinary spotted area. But it is quite otherwise with the first class of veiled spots, which, except for their diminished brilliancy, would have nothing in common with the fully developed sun spots. Seen in all solar latitudes, they are never absent from the sun, being, with good definition, as frequent and as visible at the epoch of spot maximum as at minimum, but catching the eye more readily when markings more intense are absent from the surface. The most striking characteristic of this class of spots is the rapidity with which they invariably disappear; but, although no individual spot ever lasts more than about three minutes, the first seen may be joined in quick succession by a multitude of others similar to itself, and thus transform vast areas, and give to portions of the solar surface that blurred appearance which is so marked a feature in Janssen's magnificent sun pictures. The general distribution of these faint objects, their evanescent character, and their ill defined appearance, seem to connect them more immediately than any other feature of the solar surface with the vertical convection currents which form so important a part of the sun's internal economy.

One exceptional observation of the formation of veiled spots may be of interest, as showing the strange phenomena we may occasionally witness by a lengthened examination of the solar image. At ten hours fifteen minutes one morning a group of spots was visible on the sun, and presented no very special feature; less than half an hour later the leader of the group had shot out a number of minute bodies, apparently, and then five minutes sufficed for all these to be transformed into veiled spots, which disappeared as rapidly as usual. Instances have not been wanting of other moving bodies seen upon the solar surface, always rapid in their course, and sometimes disappearing without crossing the limb. I refer, of course, only to observations in which every precaution was taken to test the objective nature of these bodies, as false images might so easily deceive a tired retina, especially after exposure to a strong light. But there would be little use in dwelling upon even well established cases of this nature, as they all probably find their explanation in the passage of bodies between the sun and the observer, and promise very little additional light for an inquiry into the nature of the solar photosphere.

Before concluding these few words on a series of solar observations of the last ten years, I may be expected by some to add one more to the already long list of solar theories, or at least to pass in rapid review the most plausible theories that up to the present time have been advanced for reducing to harmony all the well established facts regarding the sun with which we are acquainted. But considering the scope of my discourse, which has dwelt mostly on the work done at a single observatory, and, even so, has only treated in detail one method of examining the solar photosphere, I should not be warranted in advancing any theory of my own, or in judging of the theories of others, without first considering the many important facts connected with our subject which the spectroscope has taught us and also extending my researches to the solar chromosphere and the corona. It is only by diligently collating the facts laboriously accumulated by telescope and spectroscope in every known region of the sun that we may hope at last to build up a complete and satisfactory solar theory. Much has already been achieved in this direction, and we are in possession, not only of reliable data, but also of important deductions therefrom, which may serve as a solid foundation for some future superstructure. I may have added, perhaps, some little toward the completion of the edifice if I have convinced you this evening that, by the persevering and judicious use of the pencil, we may yet hope to throw some light on questions of solar physics that might not so readily have been secured by any other means.

THE GERMANS IN EAST AFRICA.

AFTER the destruction of Buschiri's camp, the next task for Wissmann and the German squadron on the East African coast was the capture of Saadani. The 12,000 to 15,000 negro inhabitants of this place had joined the insurgents, and the few Arabs that lived there were also Buschiri's friends. On June 5, Wissmann's troops in the camp near Bagamoyo received orders to hold themselves ready to march, and at midnight of the same day they embarked on the Euch, a steamer chartered to take them to Saadani. After all were on board the steamer started northward, towing a chain of boats of all sorts. The Euch anchored ten miles from Saadani, and at 6 o'clock in the morning of June 6 the war ships Leipzig, Pfeil, Möve, and Schwalbe passed her and began to bombard Saadani. Under the thunder of their guns the troops disembarked, which was rather a difficult undertaking, as our illustration shows. When the boats had approached to within about 1,640 yards of the shore, a lively firing began in the bushes along the coast, which was soon silenced, however, by the revolving guns of the launches. Scarcely had the occupants of the first boat seen that there was ground under them than they sprang overboard, and hastened through water up to their arms, shouting. The officers of the second boat, and then the others, followed their example. Our cut shows the German officers wading breast deep, holding their guns above the water and urging their soldiers to advance. Soon the companies were ready for attack, and as the enemy had vacated the town, it was soon taken. Only a slight resistance was offered at the southwest end. The town was burned, and several Arabs and negroes who had remained were shot, and an old Indian was taken prisoner. The loss of the Germans was small, one under-officer having been wounded in the hand, one Zulu killed and two other blacks slightly wounded. At one o'clock that night the whole town was in flames, and Wissmann's troops went back, in boats, to the Euch, and were taken to Bagamoyo.—*Illustrirte Zeitung.*

JOSEPH WADE, CENTENARIAN.

THE subject of this sketch was a son of Sylvanus Wade, and a grandson of Capt. John Wade, the latter being the great-grandson of Jonathan Wade, who,

JOSEPH WADE, CENTENARIAN.

with Susana, his wife, came from Ipswich, Essex county, England, to the colony of Massachusetts Bay, about the year 1630. Capt. John Wade was born at Bridgewater, Mass., in 1725, and died at Granville, Nova Scotia, in 1813, aged 88 years. Of his five children, his second son, the father of Joseph Wade, was born in Bridgewater, Mass., and married Elizabeth Troop, of Annapolis, Nova Scotia, in 1783. Of these parents, Joseph was the second son in a family of six boys, and was born at Granville, N. S., April 23, 1786, dying at the same place January 29, 1888, thus lacking a little less than three months of being 102 years of age.

Capt. John Wade, the grandfather of the centenarian, had considerable military experience, serving in the expedition which took Louisburg, on Cape Breton Island, in 1758, and, with his Massachusetts company under Gen. Wolfe, at the subsequent capture of Quebec. After the conclusion of peace, Capt. Wade received a grant of land in that most beautiful portion of Nova Scotia from which the Acadians had been expelled by the English, the story of which is so thrillingly told in Longfellow's Evangeline. Many other New Englanders were also settled in this neighborhood at the time, and here the subject of this sketch was born and lived all his life, finding here also his burying place.

The estate lies in a beautiful vale, at the western head of a mountain which shuts out the air currents from the foggy Bay of Fundy for a reach of a hundred miles, while it shuts in the beautiful Annapolis Basin. The occupation of Mr. Wade was that of a farmer, but in early life he owned and managed a small chair factory, the seats of the chairs being made of rushes tightly twisted together. He was an exemplary citizen, industrious and strictly temperate. For more than forty years he was a deacon of the Baptist church, and up to his 98th year never missed a communion service, attending church the Sunday after his 100th birthday.

As for his remarkable longevity—he inherited a strong body from robust ancestors; his farmer's occupation enabled him to spend most of his time in the open air, where the natural scenery had a most agreeable variety; his food was plain but of the best quality; he always rose early and retired early, sleeping soundly all night; he was extremely regular and methodical in all he did, never allowing his work to drive or hurry him, and cultivated a naturally happy and cheerful disposition. His means were moderate, and he was content therewith. During his long life he was never sick and never called a physician. He always shaved himself, and he did this till within seven days of his death. His hearing was not impaired, and his eyes never grew dim. His last and only illness, if illness it can be called, was simply one week of quiet going out.

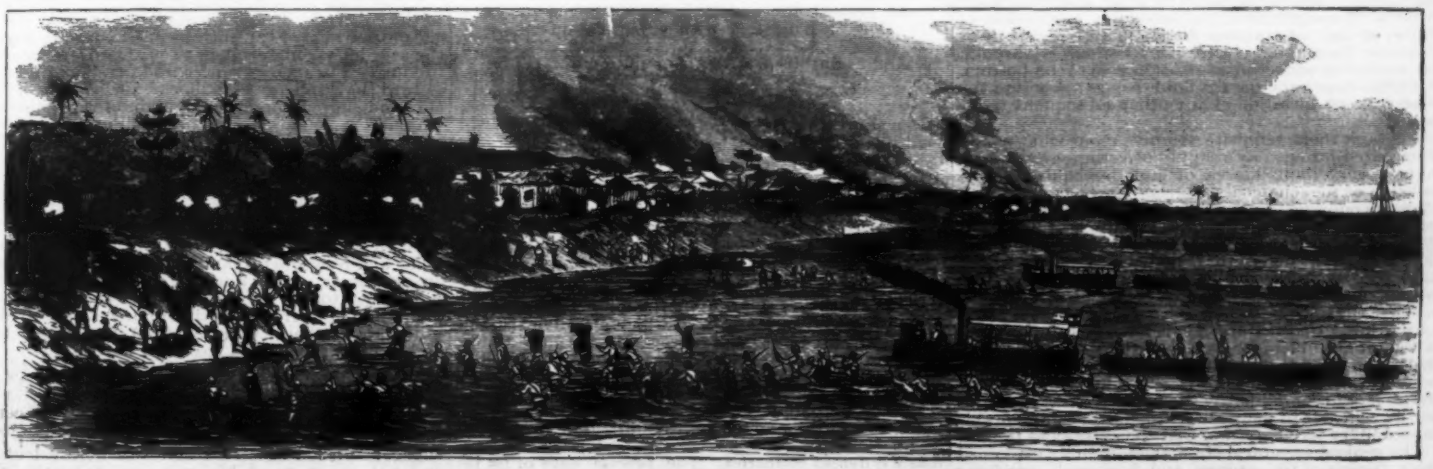
ARSENIC AS A POISON AND A MEDICINE.

ARSENICOS, a Greek word signifying "masculine," furnished the name of the famous poison which has of late claimed so large a share of public attention. During the past two thousand years this substance has held the premier position in its class, and has played no inconsiderable part in the history of royal intrigues and perfidies. Masculine enough in its characters and properties, arsenic has always been the favorite weapon of the female assassin, and its history is linked obscurely but certainly with many of the most romantic records of the villainy of the early and middle ages. The sorceresses of Rome followed a risky but generally a lucrative avocation.

Locusta, the most famous of them all, had a laboratory in the place of Nero, and was loaded with wealth and favors for the infamous services she rendered to the tyrant in ridding him of his enemies. Subsequently she fell a victim to a wave of morality which influenced either that monarch or his successor, Galba. But she was only one of a tribe who for centuries prosecuted their crimes with varying fortunes amid the high life of the Rome of the Cæsars. There is little doubt that arsenic was the final resort of these wretches when their skill was called upon for the most serious plots, though aconite seems to have been an almost equally trusted weapon, so much so, indeed, that in the time of Trajan its cultivation was forbidden. But France and Italy probably surpassed Rome in its worst days as a field for the exercise of the female poisoner's talents. In the latter half of the sixteenth century Paris swarmed with witches, most of whom were adepts at poisoning. Confectionery was the usual medium, and arsenic the almost universal poison employed.

In the next century Italy furnished the most skillful practitioners, and the murder of unloved husbands, wealthy uncles, and inconvenient rivals became a social scandal of the gravest peril. The *acquetta di Napoli* or *acquetta Tofano* and the *poudre de succession* attained the celebrity which patent medicines of the present day can only reach after the expenditure of fabulous sums of money. The exploits of the woman Tofana, as narrated by herself to the Emperor Charles VI. and the Pope Alexander VII., after she had been put to the torture, revealed a remorseless cruelty almost incredible in its completeness. Her liquid was an arsenical solution of great concentration, which was supplied in small glass bottles engraved with the words "Manna of St. Nicolas of Bari," and bearing an image of the saint.

Four or six drops was a fatal dose, but it was usual for this woman and her disciples to predict the day of the death of their victims, and to bring their prophecies to pass by the careful administration of gradually increasing doses. The *acquetta Tofana* is said to have caused the deaths of two popes, Pius III. and Clement XIV., and of not less than 600 meaner people. A disciple of Tofana's named Hieronyma Spara formed an association of young Italian married women, who made it their business to poison their own and other people's husbands. Four members of this precious gang were burned under the popedom of Alexander VII. The beautiful but infamous Marchioness of Brinvilliers, who was executed in Paris some years



WISSMANN'S EXPEDITION IN EAST AFRICA—THE STORMING OF SAADANI.

later, and who had poisoned, besides others, her father, her brothers, and a sister, had learned to compound her deadly mixtures from her lover, St. Croix, who had himself acquired the art from an Italian prisoner, Exili, with whom he had associated in the Bastille, and who was believed to have been a pupil of Tofana.

This Marchioness of Brinvilliers at one period of her career assumed the garb of a sister of mercy, and in that guise worked as a nurse in the Hotel Dieu, where she is believed to have experimented on the patients committed to her care with the concoctions which she afterward used on her friends with such deadly effect. Two centuries ago tribunals had no chemical means of detecting the presence of arsenic such as we are acquainted with; now no poison can be more certainly discovered. But it still appears in famous trials as the favorite instrument of murder which beautiful women are charged with having employed.

The case of Madeline Smith has been frequently mentioned in the last month by commentators on the Maybrick trial. In that case the charge was found by a jury, and in this by a large section of the public, to have been "Not proven," and we heartily hope, for the credit of our age, that both women were innocent of the guilt attributed to them. But the accusations and the circumstances compel the memory to turn to the pages of history which we have mentioned, and serve to show how powerful science has proved in the contest with crime. Tofana and her associates, with their little bottles of arsenic, were a really terrible power in their days, chiefly on account of the subtlety of the weapons they employed. Merciless murderesses of their class are almost inconceivable in this century; but if such could or do exist, they are at least deprived of the mystery which was their most efficient ally. Chemical analysis is far cleverer than their methods can be, and it compels them to a large degree to fight in the open. This is the greatest guarantee of safety which society can acquire.

Several correspondents have directed attention to the suggestion that arsenic is used externally as a cosmetic. There appears to be but very slight foundation for this assumption, though arsenic is recommended in medical works as an external application in certain parasitic skin diseases. One of the witnesses in the Maybrick trial, Mr. Edwin Stanton, a retired chemist, but formerly in business near the Liverpool Exchange, gave evidence that the late Mr. Maybrick was in the habit of coming to his shop for a pick-me-up. The particular pick-me-up which Mr. Maybrick took was made from a prescription.

Originally it contained four drops of liq. arsenicalis to each dose, but gradually this dose was increased to seven drops, and Mr. Maybrick would take that from two to five times daily. It further appeared from Mr. Stanton's evidence that an arsenical pick-me-up was taken by other customers. "It was very much used," he said. "Some people would take it several times a day. I should not say it was very common to add arsenic to the tonic." Mr. Maybrick, it is said, took the poison as an aphrodisiac. The value of arsenical treatment in ague, phthisis, and in certain neuralgic and dyspeptic complaints is well established. But there is very little satisfactory evidence of its tonic virtues beyond the interesting but by no means perfect reports which have been published from time to time of its use by the Styrian mountaineers. It is certain that its value cannot be at all equal to its danger when taken carelessly and frequently in pick-me-ups. There is, moreover, substantial evidence that the abandonment of the medicine after the practice of taking it has been acquired is attended with depression and emaciation; and this fact should suffice to prevent chemists from encouraging its use in the form indicated by Mr. Stanton. We should be surprised to learn that such pick-me-ups as he administered are dispensed at all frequently, either in Liverpool or elsewhere.—*Chemist and Druggist.*

SEWAGE WORKS FOR LARGE AND SMALL TOWNS.

THE KINGSTON SEWAGE WORKS.

THE sewage of Kingston and Surbiton is treated by the well known system of the Native Guano Company, limited.

The company claim for their process:

1. That the effluent water therefrom is sufficiently purified to be admissible into any river within the requirements of the Rivers Pollution Prevention Act, and without injury to fish.
2. That this is effected without nuisance.
3. That the materials used in the process do not injure or destroy the manurial qualities of the sewage, which are consequently preserved for agricultural use in a dry, portable, and inoffensive form.

The sewage is received in tanks, in its passage to which it receives, first, a mixture of clay, charcoal, and a small quantity of blood or other glutinous body capable of coagulation, and secondly, a solution of crude sulphate of alumina distributed in such wise as to secure thorough mixture. In its progress through the tanks the matter in suspension goes to the bottom, while the clear supernatant fluid passes away into the river without filtration or any other subsequent treatment.

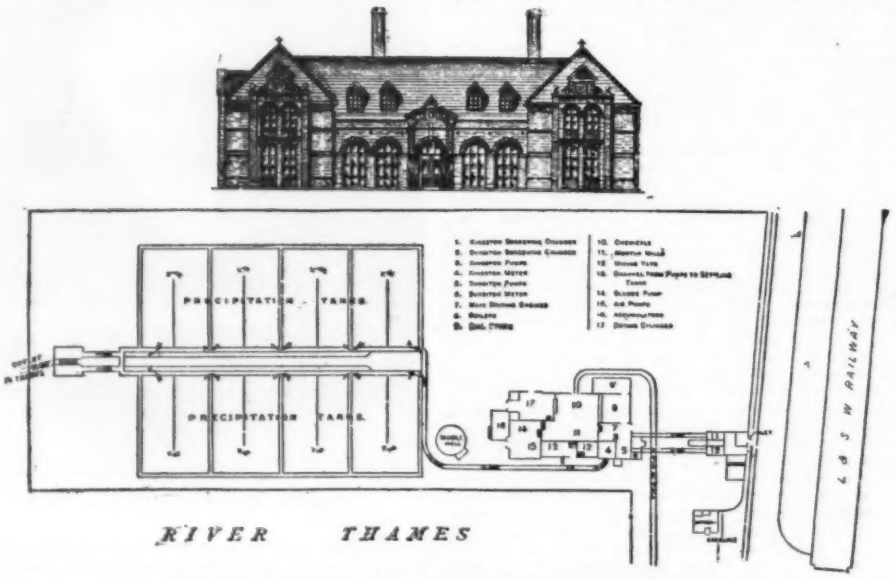
The tank room requisite is only about what would be required for one day's supply of sewage, and accordingly a very limited area of land is required. The addition of the charcoal and clay at once arrests all offensive odor, no matter how foul the sewage may be, and this freedom from nuisance continues throughout the whole of the process. The tanks are cleaned periodically. The deposit or "sludge" is pumped into filter presses, where the superabundant moisture is removed, and further dried by artificial heat till it assumes the appearance of dry earth, when it is ready for market. One feature of this process is that no lime is used at all, unless a test shows the sewage entering the works to be abnormally acid from manufacturing refuse, in which case it is, of course, necessary to neutralize it, and consequently the effluent always remains on the acid side of neutrality, a condition unfavorable to secondary fermentation, and hence sewage fungus.

The general secretary, Mr. Cameron Sillar, explained the *rationale* of the process and how each purifying agent worked. Alluding to the clay, he said their process might be described as the reverse of irrigation, for they brought the earth to the sewage instead of the sewage to the earth. The charcoal used was a waste product of another manufacture, and, in fact, the sulphate of alumina was the only chemical used which could not be had at the mere cost of carriage.

The accompanying sketches show a front view of the buildings and a block plan of the works. The Kingston sewage on reaching the works passes into the screening chamber and through a grating, which intercepts coarse matter likely to choke or injure the pumps, and thence through a culvert to a pump well under the main building, where it receives the charcoal, clay, and blood.

The sewage thus partially treated is raised about 12 feet by centrifugal pumps, of which there are three, each driven by a 15 horse power engine and capable of lifting 1,650 gallons per minute. The pumps discharge into a meter chamber where the sewage is measured and the quantity registered. On leaving the meter the sewage flows along an open channel to the settling tanks, receiving on its way the precipitating agents. There are eight tanks, each 85 feet long by 50 feet broad and 6 feet average working depth, holding 150,000 gallons, or 1,200,000 gallons in the aggregate, which gives a capacity of 30 gallons per head for a population of 40,000. The treated sewage flows in a continuous stream through the tanks, precipitating as it flows, and passes clear, bright, and odorless into a covered channel discharging into the Thames.

The tanks are cleaned periodically, the deposit or "sludge" being pumped into the sludge well by a Tangye-Holman double-action pump at the rate of 500 gallons per minute. From this well the sludge is first drawn into four sludge vessels, or accumulators, by the creation of a vacuum, and is then forced by air pressure at 100 lb. on the square inch into filter presses on the first floor of the building, from which it is removed in hard cakes. There are two of Scott's air pumps and 11 of the Native Guano Company's filter presses. The pressed cakes are dried in a Borwick's drying cylinder (with fan and condensing apparatus attached), ground into powder, and sold as native guano. The Surbiton sewage is separately received and screened, and is pumped by centrifugal pumps, through



SEWAGE WORKS FOR LARGE AND SMALL TOWNS.

a meter, into the Kingston pump well. There are three pumps, each driven by an 8 horse power engine, and capable of lifting 750 gallons per minute. The boilers are of the locomotive multitubular type, working at a pressure of 150 lb. per square inch—one of 80 horse power and two of 60 horse power each. The two main driving engines, each of 40 horse power, are used alternately, and, like the pump engines, are of Messrs. Willans & Robinson's patent kind. Two mortar mills are used for grinding the deodorizers, which are then mixed in vats and discharged into the pump well; and there are two vats for dissolving the precipitating agents. A small centrifugal pump supplies water from the river for the boilers, mixing the chemicals, etc. The works have been constructed for treating, by the Native Guano Company's processes, the sewage of 35,000 people; but with certain comparatively inexpensive additions, they will meet the requirements of a population of 50,000.

At present the sewage being treated is that of Kingston, with a population of	26,156
And of Surbiton, with a population of	11,912
Total	38,068

In a short time Hampton Wick (population 2,500) will send its sewage over the railway bridge to these works by one of Shone's ejectors.—*Jour. Soc. Chem. Industry.*

A SHORT ACCOUNT OF THE OPIUM INDUSTRY IN THE N. W. PROVINCES AND OUDH.*

By P. A. WEIR, M.B.

AT the request of the secretary I have compiled, for the information of the section, the following notes, the greater part of the material of which already exists on record, for the most part, however, in the official publications of the governments of Bengal and of India, which are not perhaps within reach of many in this country.

The opium poppy is a native of Asia Minor, but having been so long and generally cultivated in Europe and parts of Asia, it is now naturalized less or more in many different countries. The precise date of its introduction to India is unknown, but it can be traced as far back as the 16th century, during the latter half of which the produce of the opium monopoly in the sarkars of Allahabad and in Ghazipur was 1,000 chests, according to the A'in Akhbar of Abul Fazul. It had attained considerable importance by 1786, at which time Lord Cornwallis wrote a minute respecting the best method of deriving a revenue from opium. It has now been long extensively cultivated in the Upper Gangetic plain, in Behar, Bundelkhand, and Malwa. "The area under poppy cultivation in the N. W. Provinces and Oudh is scattered over 38 of the 49 revenue districts in these provinces, and occupies more than ¼ million acres, and necessitates the employment of no less than 2⅓ million persons in the fields." For the Chinese market the opium of the Behar and Benares agencies is commercially the best, as being the most approved by the Chinese, although *officinally* it is inferior to the Smyrna drug.

The cultivation of opium in India in British territory is a government monopoly, existing for the benefit of the imperial revenue. The opium department is for convenience administered, under the Lieutenant-Governor of Bengal, by the Board of Revenue of the Lower Provinces. Subordinate to the board are the two opium agents, each of whom is in charge of one of the two opium agencies. One of these is the Behar agency, with its headquarters at Patna, and situated entirely in the Lower Provinces. The other is the Benares opium agency, situated in the N. W. Provinces and Oudh, and having headquarters at Ghazipur, on the Ganges, about 40 miles from Benares. In each agency there are under the agent two sets of officials, the district officers concerned with the production of the raw material and the factory staff occupied in its manufacture.

The system of cultivation at present in force in British territory is briefly as follows: No poppy is allowed to be grown save with the permission of government. Government grants this permission to suitable cultivators on condition that only a certain definitely agreed on area of land shall be sown by each with poppy, and that the entire produce shall be made over at the proper time to the agents of government in exchange for its value in cash, calculated at the rate (at present) of Rs. 5 per ser of 70° consistence. (70° consistence opium is opium of which 100 grammes when dried at 100° C. yield 70 grammes residue. Opium of this consistence is called standard opium.) Permits or licenses to grow poppy are issued in the period from August to October, at which time the district officers meet the would-be cultivators or their agents and settle more or less directly with each the area he is to be allowed to cultivate. The experience of many seasons, as recorded in the books of his office for each locality, enables a district officer to estimate very closely the average quantity of standard opium that the particular area licensed to any cultivator is likely to produce. In this way the district officer is able to keep within the limits of the quantity his district has been called on to supply, which quantity in turn is based on the indent sent down by government to the agent, and by him apportioned among the districts under his charge.

At the time of settlement the district officer makes to the cultivator a cash advance of a certain percentage of the value of the outturn of standard opium that the area he has undertaken to cultivate is estimated to produce. For such advances, and for similar advances toward the purchase of bullocks, the sinking of wells, etc., and aggregating over 200 lakhs of rupees (nominal two million pounds sterling) per annum, no interest is charged by government, the cultivator enjoying the use of the money free. The advances are in due course recovered in the shape mainly of produce, the balances being paid up in cash, and outstandings of any size are little known.

Having settled with the district officer, and been licensed to sow a certain area, the cultivator returns home and prepares his land, and makes other necessary arrangements, and in due course, about November, he commences to sow his seed. During the growth of the plant, the industrious cultivator takes care to attend to its proper tillage, watering it at the proper times, and keeping the ground free from weeds.

During this season the district officer with his staff goes on tour throughout the area under his charge—which may measure many hundred square miles—in order to measure the ground cultivated by each licensee for the purpose of seeing that he has sown up to his engagements (on which his advances were calculated), and not in excess of his engagements (as this would throw out the arrangements for complying exactly with the indent sent down by government); to see

* *Journal* of the Society of Chemical Industry.

that the cultivation is being carried on in a proper manner (the plant being watered as required, and the soil kept clear of weeds), and that no other crops are being simultaneously cultivated in the poppy field; to give, if necessary, a further cash advance on account of the value of the estimated out-turn; to see that no illicit poppy cultivation is being practiced (which would lead to smuggling and to the defrauding of the excise revenue); and to report periodically to the agent on the general prospects of the crop.

About the beginning of February the plants begin to flower. At this time is begun in certain districts the preparation of "leaf." "Leaf" is the technical name for the material used at the factory to form the shell of the opium cake in course of provision for the China market. About the close of the third day of the flower's expansion the petals are in such a stage of maturity that they are ready to drop off the top of the seed vessel at a touch; at this stage the cultivators go through the fields in the afternoon and collect the petals or carry them home. In the evening, after she has baked her husband's bannock, the cultivator's wife takes two or three handfuls of the petals and throws them on the top of the hot griddle iron, and as the gummy juice of the petals exudes by the heat, she presses the petals down by a damp cloth which she skillfully manipulates, until what with the steam from the cloth and the gum in the leaves, the petals become agglutinated, and ultimately take the pancake-like form of the so-called "leaf." The leaves are carefully dried, and are in due course brought by the cultivator to the district officer, who receives them on behalf of the government, and pays for them, according to their quality, at from Rs. 10 to 5 a per maund (of 82⅔ lb.), and forwards them to the factory at the headquarters of the agency for disposal.

The annual consumption of "leaf" in the preparation of the shells of the provision of opium for the China market is very large—amounting to from 16 to 20,000 maunds—representing the petals of over 5,000 million flowers according to Scott's calculations.

In the course of from 7 to 10 days from the fall of the flower leaves, the capsules are sufficiently mature for the extraction of the drug, becoming plump and firm, and coated with a fine whitish bloom.

The incisions are now commenced, and are carried on regularly every third day, and according to the condition of the plant, and the time of the collection, the number of lancings required to extract all the juice varies from one to five or six, and perhaps seven in isolated cases. The lancing is carried on in the afternoon, and consists of three or four vertical incisions performed at one operation by three or four primitive lancets tied together with cotton thread. The juice exudes slowly, and is milky white at first, the outer part of the tear gradually changing to a pinky salmon color. Next morning the tears that have exuded are scraped off by an iron trowel-shaped scraper and put into a metal dish, from which at the cultivator's house they are transferred to unglazed earthen vessels set atilt to allow excess of watery matter and pasewa to drain off. The aggregate of the drug belonging to a cultivator is kept in a shady place in his house, and carefully treated so as not to injure the grain, but to allow the consistence to rise evenly until it has reached the desired degree. The opium is then brought to the district officer at the appointed time and place, and he receives it over by weight on behalf of government, and transmits it to the factory in jars containing one maund (82⅔ lb.) each, paying to the cultivator a further advance on its value according to his estimate of its assay. The annual amount of opium delivered in the two agencies amounts to perhaps 107,000 maunds at 70° (equal to about 3,900 tons, and for which the cultivator would receive Rs. 2,14,00,000, nominally 2¼ million pounds sterling).

After the collection of the opium has ceased, the plants are allowed to remain standing in the fields till the capsules are quite ripe; these are then collected, and the plant leaves when dry are, in certain districts, gathered and sent into the factory under the name of *trash*, to be used as dunnage in packing the provision opium for China. Trash is paid for in the Benares agency at about 10 annas per maund. The annual out-turn of trash in the two agencies is more than 28,000 maunds,.

The opium on arrival at the factory is, after weighment, examined jar by jar by the opium examiner, who certifies to its quality and purity. It then has its consistence determined for each jar by assay on the steam table, and according to its consistence it is stored away in one or other of the extensive ranging store vats in the malkhana or storehouse, some of which hold 3,000 maunds. The final payments to the cultivators are made according to the value of the opium as determined by its consistence on assay at the factory.

When a sufficient quantity of suitable opium has been received into the factory, the manufacture of the provision of opium for the China market is commenced. The provision is caked at the consistence of 70°. To this end quantities of opium of consistencies above and below 70° are alligated or mixed together in certain proportions, so that the mean consistence of the mixture may fall within the limits allowed. Before issue from the caking vats the opium in them is assayed for consistence to insure that it does not fall below the caking standard laid down by government.

For *each* "cake" there are served out the equivalent of a certain weight of standard opium for the central mass, together with a certain measure of "*lewa*," the equivalent of a fixed weight of standard opium. Lewa is a paste made of opium broken up in water, and is of 52·5° consistence. For each cake is also issued a certain weight of leaf, which is previously damped to make it flexible and non-friable.

In a hemispherical brass cup of about 6 in. diameter, the cake maker pastes layer after layer of pieces of leaf which he gums together with lewa until the thickness of the hemisphere of shell in the cup is ⅛ in., and over the edges of the mould he allows the free ends of the pieces of leaf in the cup to hang. The opium is then deposited in the center of the hemisphere of shell in the cup, and over it the overhanging leaves are brought and carefully imbricated and pasted down with lewa, and bound together by fresh portions of leaf, and finally over all one of the finest leaves is pasted on and a complete sphere results. This is turned out of the cup and covered half way up with "trash," which prevents its sticking to the inside of the porous earthenware cup into which the cake is now put. The cup and cake are put on a shelf in a well ventilated warehouse. Caking goes on from May till July, at the rate of about 20,000 cakes per diem. The cakes remain on the racks till they are fit for packing, and each cake is periodically turned about in the cup so that it shall dry regularly and evenly, and preserve its spherical shape.

Packing begins about the middle of November. Previous to the commencement of the season's packing the chief civil officer or magistrate of the district visits the factory and selects at random out of the whole stock of provision in the factory six cakes for analysis; two are retained at the factory, two sent to the sister factory, and two go to the chemical examiner to government at Calcutta. The results of the analysis of each of these three sets of two cakes (in terms of their morphia, narcotine, and smokable extract) are put on the table at the first sale of the season's opium, for the information of the merchants.

Packing is carried on in fine weather only, and is not practicable in damp, cloudy, or rainy weather. Twenty thousand cakes are packed daily in 500 chests, 40 cakes in a chest, the dunnage used being the "trash" already described. Five hundred chests a day are daily dispatched from the factory *en route* for Calcutta, where they are stored in large warehouses under the charge of the board of revenue, by whom a certain number are exposed for sale each month on account of the imperial government.

The opium intended for Indian consumption is not made up into balls of 70° consistence; it is exposed in the sun in shallow trays until it has become inspissated to a consistence of 90°, at which point it is melted into cubical cakes of 1 ser, each of which is smeared with poppy oil and packed in two layers of bamboo paper. The cakes are then packed in sixties in mango wood chests, which are distributed as required to the different treasuries of the N. W. Provinces and Oudh and Central Provinces.

Opium which, on examination at either factory, is found to be adulterated or otherwise unfit for manufacture, is confiscated, and the morphia and codeia in it are recovered in the laboratory department of the Ghazipur factory. Narcotine used also to be recovered; the demand for it has, however, now almost entirely ceased, and it is no longer prepared at Ghazipur.

"The cultivation of the poppy is popular among our cultivators, . . . the certainty of receiving a fixed price for their opium, the payment of advances without interest at periods at which the Asamis are generally hard pressed for funds; the obtaining high prices both for the poppy petals and leaves; the getting advances free of interest for wells and frequently for purchase of bullocks, and the remission of all the advances outstanding if their crop has been destroyed by hail; these advantages and the large profits derived from opium attach the Asamis to the cultivation and make it popular. Hindoos of all castes, from Brahmins down to Chamars, and Mohammedans, too, cultivate poppy, but the Koeri caste are our best cultivators." (Turnbull.)

In one year, for an actual cultivation area of 899,287 bighas (562,054 imp. acres), cultivated by 1,448,508 Asamis, the out-turn of opium at 70° consistence was 107,577 maunds (3,952 tons), for which were paid to the cultivators in hard cash Rs. 2,15,15,400 (two and one-seventh million pounds sterling nominal), besides which 19,872 maunds of leaf and 28,773 maunds of trash were supplied and paid for.

In the same year there were turned out (from confiscated useless opium):

	Lb.
Codeia	34
Morphia acetate	34
" hydrate	202
" sulphate	17

DISCUSSION.

The chairman said he would be obliged if Dr. Weir would tell the meeting: What was the amount of morphia in the opium? Was the leaf that had been shown round—and which he presumed was a collection of poppy petals—used for any other purpose than covering the opium? Did the said leaf contain any morphia? A curious fact he had noticed was that the red poppy which was so common in the fields in this country, and which bore such a strong smell of opium, did not contain morphia. Why did a Chinaman prefer to smoke opium that contained little or no morphia?

Dr. Weir, in reply to the chairman, said that the amount of morphia in the opium was from 2 to 5 per cent.; that the leaf referred to was not used for any other purpose than covering the opium, and that it did not contain any morphia. The Chinaman preferred to smoke opium that contained little or no morphia because if not used to excess it would do him no harm.

ON THE INTENTIONAL IMPORTATION OF PARASITES AND NATURAL ENEMIES OF INSECTS INJURIOUS TO VEGETATION.*

By C. V. RILEY, Ph.D.

MOST persons who have given attention to the subject of economic entomology must have meditated upon the subject of this paper, and many have recognized its importance. In my work, both State and national, I have had repeated occasion of calling attention to the subject, and have made various efforts to artificially import the insect enemies of species injurious to vegetation, into regions in which the injurious species was at work without them.

This encouragement of the natural checks to the increase of an injurious species may be of a twofold nature. It frequently happens that an indigenous species is found to have certain parasites in only a portion of the country which it inhabits. In such cases, where it is practical to transport the parasites, a great deal of good may be accomplished. Cases in point are not uncommon. Some of the Chalcid and Mymarid parasites of certain scale insects (family Coccidæ) are thus easily sent from one place to another. (Cf. my 3d, 4th, and 5th reports on the insects of Missouri, 1870–72.) Again, in the case of the plum curculio (*Conotrcahelus nenuphar*), a widespread indigenous snout beetle which seriously affects the plum and a great deal of other stone fruit. This beetle is known to have certain Braconid parasites which undergo their transformation below ground, the larva forming a tough cocoon in which it or the pupa is easily transported through the mails. (*Vide* 3d Mo. Rep., 1870.) Other similar cases will occur to the experienced.

But this intentional distribution of the parasites or natural enemies of an injurious insect from one part to another of its native country is not to be compared in importance with the introduction of such parasites or enemies from one country to another in which the injurious species has obtained a foothold without the corresponding natural enemies which serve to keep it in check in its original home.

The object of the present communication is to cite an illustration of this kind of artificial introduction on a large scale which has already been productive of great good. A successful attempt of this kind has been made by me in the case of *Microgaster glomeratus*, which, after several futile efforts, was introduced from Europe and established in the United States in 1885, and which has now become so widely distributed as to raise the question of its previous existence here. This microgaster is one of the commonest parasites of the European cabbage worm, *Pieris rapæ*, which was introduced and naturalized in America without its European enemies about the year 1859, and which rapidly spread over many of the States and parts of Canada with disastrous results to the cabbage crop.

The case to which I would particularly allude is, however, far more important and satisfactory. Orange culture has become a very important industry in Southern California. The orange groves there have suffered for some years from the attacks of several insects, but particularly of a very pernicious scale insect, *Icerya purchasi*, Maskell. This is one of our largest coccids, and from its habits and characteristics very difficult to overcome. It does a great deal of damage, not only to the orange and other citrous fruit trees, but to many other cultivated plants. The damage has become so serious during the past few years that many orange growers have abandoned their groves, while the cost and trouble of protecting them by the use of insecticides have always been great, even where successful. After very careful researches I ascertained that the insect was, without question, a native of Australia, and had been artificially introduced not only into Southern California, but also into Cape Colony, in South Africa, and probably into New Zealand; also that in its native home it rarely did serious damage, being kept in check there by various natural enemies and parasites. Some attempt was made through correspondence with Mr. Frazer Crawford, of Adelaide, to introduce one of the parasites by mail in 1887. Specimens were received alive and liberated at Los Angeles under confinement; but no positive evidence was obtained of multiplication or colonization. Special effort and introduction on a larger scale seemed necessary. Last autumn and winter, in connection with the commission appointed to visit the Melbourne International Exposition, and through the State department, I was able to send one of my field agents, Mr. Albert Koebele, to Australia, with instructions to study these natural enemies and to send living specimens to California. The principal facts have been recorded in my last annual report as Entomologist of the United States Department of Agriculture and in late numbers of *Insect Life*, a monthly bulletin published under the auspices of the entomologist and his assistants. Without going into detail I may say that Mr. Koebele's mission has been eminently successful, and that we have succeeded in introducing alive not only the most important of the parasites, an interesting Dipteron (*Lestophonus iceryæ*, Williston), but also several predaceous species, and particularly certain ladybirds (Coccinellidæ). These were brought over last winter and spring, and have become well acclimated, and are now spreading and multiplying at a rapid rate. The latest reports which I have received from California are to the effect that one of the commoner ladybirds, but recently described, namely, the *Vedolia cardinalis*, and another lately described by Dr. D. Sharp as *Scymnus restitutor*, are multiplying and spreading in a most satisfactory manner. The consignments from Australia were received at Los Angeles by Dr. D. W. Coquillett, another of the agents of the division.

The first consignment of the *Vedolia* was received November 30, 1888, and numbered 28 living specimens of larvæ, pupæ, and beetles; the second consignment was received December 29, and contained 45 specimens in their different stages, and a third consignment of 56 specimens was received January 24 of this year, making in all 129 specimens, which were placed under tent. From the very first, these Coccinellidæ throve and played havoc with the Iceryas. By the latter part of April they had increased to such an extent that it was deemed advisable to send out colonies to different parts of the State, and up to date of my last advices, the beginning of June, over 4,000 specimens had been sent to various parties who had applied for them, while there were fully 2,000 specimens still remaining where colonized. "These 6,000 individuals," writes Mr. Coquillett, "are the progeny of the original 129 insects referred to above, which will give some idea of the rapidity with which these insects breed. Several of the orange trees at Mr. Wolfskill's have been almost entirely cleared of the Iceryas by these ladybirds, and on the other trees their numbers are becoming rapidly lessened through the persistent attacks of their merciless foes."

Besides the 129 specimens referred to above, two later consignments were received. One of these arrived February 21 and consisted of 35 specimens, which were colonized on an orange tree in the San Gabriel Valley. A much larger consignment, containing about 350 specimens in different stages, was received March 20, some of which were also colonized at the same place, while the remainder were placed in another grove.

The increase of the *Lestophonus* is more slow. Speaking of these importations in my last report (p. 90), I remarked: "We fully expect to learn of the increase and rapid spread of this new introduction, as well as of some of the other predaceous species which have been introduced, and to find that in a comparatively few years the orange groves of Southern California will be kept measurably free of the pernicious fluted scale without so great an effort on the part of the growers or so great an expense in destroying it. That nature will, with the new conditions induced by these importations,

* Read before the American Association for the Advancement of Science, at Toronto, September, 1889.

come to the relief of the fruit grower, and that this interesting experiment will result in the ultimate saving of untold millions to the people of the Pacific coast, is our sincere belief, which we hope to live to see verified. Not that we expect to see the Icerya to be ever entirely exterminated; but it will be kept under subjection, so as to be comparatively harmless, as it is in its native country."

These predictions are in a fair way of realization, and the instance is of sufficient scientific and economic interest to be presented to the Association.

Paris, France, Aug. 6, 1889.

THIOCAMF--A NEW DISINFECTANT MATERIAL.*

By J. EMERSON REYNOLDS, M.D., F.R.S.

EVERY practical physician is asked from time to time, "How can I most easily disinfect that room?" after infectious illness or death has occurred in a household, and the answer is by no means simple. The difficulty is to recommend anything sufficiently easy of application in which confidence can be placed.

Chloride of lime, Condy's fluid, carbolic acid, etc., are all more or less good if they can be brought into direct contact with the things to be disinfected; but that is just the difficulty in the case of a room, for mere exposure of the above named substances in solution or otherwise in a chamber is useless. If carefully *sprayed* they—especially carbolic acid—can do effective work, but thorough spraying involves the presence of the operator in the room, to his discomfort and possible danger, or the use of costly and troublesome apparatus.

It is evident then that apartments can only be disinfected in any real sense by gases or vapors of very volatile substances which are known to possess the requisite power of destroying the vitality of various bacteria. We are therefore practically reduced to chlorine gas, nitrous fumes, or sulphur dioxide gas, but all the common methods for the production of these in sufficient quantity are more or less dangerous, and disinfection by them can only be properly carried out by skilled persons, since there is risk of corrosion by powerful acids, or of setting fire to woodwork, etc.

Since writing the chapter on "Disinfection and Contagion," in the "Manual of Public Health," I have sought some simpler means than is there recommended for disinfection of rooms, so that any intelligent person could attain the end in view without risk of fire, without the use of corrosive materials, or of large quantities of any agents, and without involving the presence of the operator in the room, or the employment of special apparatus.

This search has been successful, and I have now the pleasure of bringing under your notice the singular liquid which fulfills the conditions I have just specified, and to which the name of thiocamf has been given.

The basis of this novel disinfectant is a very curious liquid which results when sulphur dioxide gas is brought in contact with camphor. At ordinary temperatures the gas alone requires a pressure of more than two atmospheres to liquefy it; but camphor, owing to chemical attraction, can liquefy the sulphur dioxide gas without any pressure whatever. In this liquid are dissolved several known bactericides. Therefore thiocamf is *all* disinfectant, but I am not free to enter into further particulars, as the patent specification has not yet been published.

A quantity of the liquid has been preserved in my laboratory for nearly two years in a corked bottle, and has not undergone sensible alteration during that time.

Thiocamf possesses almost unique properties, for while it can be preserved *without* pressure in bottles at mean temperature, mere exposure of the liquid in a thin layer to the air determines the steady evolution of relatively enormous volumes of sulphur dioxide gas from it, charged with the vapors of other powerful disinfectants. These gases and vapors diffuse through the whole of the air of a well closed room, and therefore must reach everything in the room if given reasonable time.

The question then arises whether the sulphur dioxide gas can destroy the bacteria—particularly the infective forms—when it reaches them. The evidence on this point has hitherto been of a rather loose kind, though the results led to the conclusion that sulphur dioxide gas is a powerful bactericide. Happily the truth of this conclusion has now been placed beyond doubt by a critical investigation of the subject, aided by modern methods of bacteriological study. This examination has been carried out in Paris by MM. Dubief and Bruhl, under the direction of Dr. Dujardin-Baumetz, and the results have been recently communicated to the Academy of Sciences. (*Comptes Rendus*, cviii., 324.)

Starting with air rich in germs of various kinds, and combining Miquel's method of numbering the bacteria with alkaline culture, Dubief and Bruhl found that the germs were always reduced in number after the action of diluted sulphur dioxide gas. Therefore the latter destroyed the vitality of bacteria. It was further found that the number destroyed increased with the duration of the action of the gas, and that this destructive action was accelerated when the humidity of the air was increased.

In all the experiments with the rather dilute sulphur dioxide gas used, the *latter proved particularly fatal to micrococci* and allied bacteria, whether diffused through the air of a chamber or attached to its walls. As these are organisms of the class which true disinfectants seek to destroy, this testimony to the value of sulphur dioxide is of exceptional importance.

Lastly, those investigations have shown that sulphur dioxide gas is a true bactericide even in a dry state, though longer time is then required for the production of its full effect.

The bearing of these results on the value of thiocamf is obvious, for if simple sulphur dioxide gas be the powerful bactericide MM. Dubief and Bruhl have proved, the mixture of sulphur dioxide with vapors of other disinfectants of acknowledged value should be a reliable combination. Moreover, there is no material that I know of, save thiocamf, which can give off so large a relative volume of sulphur dioxide gas (the contents of a small six ounce bottle can afford over 20,000 c. c.) without any special treatment, save exposure in a very thin layer on an old tray or dish to the air of a room to be disinfected. Further, one ounce of thiocamf shaken up with a quart of water forms a powerful disinfectant for ordinary purposes, such as sprinkling over various matters, purifying drains, etc.; while a still more dilute solution (one ounce to a gallon) can be used for soaking clothes which have been in contact with infected persons. The residue of thiocamf has a pleasant aromatic odor.

This concentrated disinfectant can now be obtained at a cheap rate, as a company formed for its manufacture can produce several hundredweight of thiocamf per week.

* Read before the Royal Dublin Society, May 22, 1889.—*Chem. News.*

VEGETABLE SKATOLE.

By WYNDHAM R. DUNSTAN, M.A., F.C.S., Professor of Chemistry to and Director of the Research Laboratory of the Pharmaceutical Society of Great Britain.

Celtis reticulosa is the name of a large tree growing in Java, whose wood possesses an intolerable odor. A few pieces of this wood, when distilled with water, yielded a minute quantity of a solid crystalline substance having a fæcal odor, which, after purification, melted at 93·5° C. It afforded a crystalline picrate, by the analysis of which the substance is shown to possess the composition of methylindole (C_9H_9N) and is proved to be identical with the Para-methyl-indole or skatole which Brieger isolated in 1877 from human fæces, and Salkowski afterward obtained from the putrefaction products of various kinds of animal proteid. Nencki has observed the formation of the same substance when potash is fused with albumen, and it has also been prepared synthetically. Skatole from *Celtis reticulosa* corresponds in all its properties with synthetical skatole from propylidene-phenylhydrazide.

The occurrence of skatole in a plant has not hitherto been observed.

Indole is associated with skatole in human fæces, but no indole could be detected in the wood of *Celtis reticulosa.—Chem. News.*

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